



Modeling in Baltimore Harbor

Technical Outreach

Prepared by

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Prepared for the

Baltimore Harbor Stakeholder Advisory Group

December 3, 2002

Harbor Toxics Modeling Program

Estimate Nonpoint Source Loads -

- **Model the watershed - estimate loads from the land to the water**
- Provide inputs to the Harbor Models
- Uses a Storm Water Management Model (SWMM)

Simulate Fate of Toxics in Baltimore Harbor – Harbor Models

■ **Management/Screen (Box Model) - UMCES**

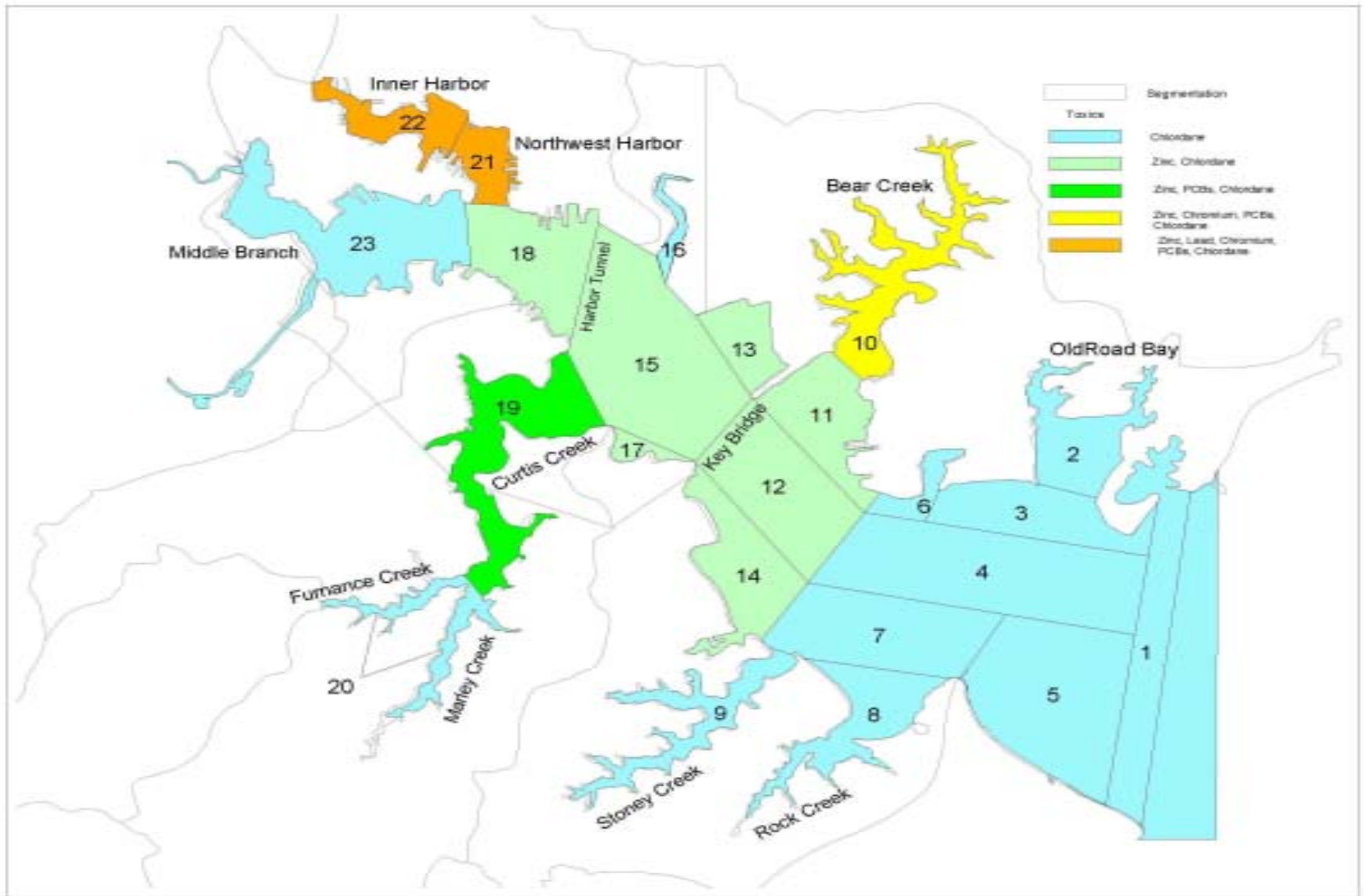
- Hydrodynamics (water transport) and Sediment Transport
- Toxic (Dissolved/Particulate)
- Food Web

■ **Detailed Assessment (Upper Bay Model) - VIMS**

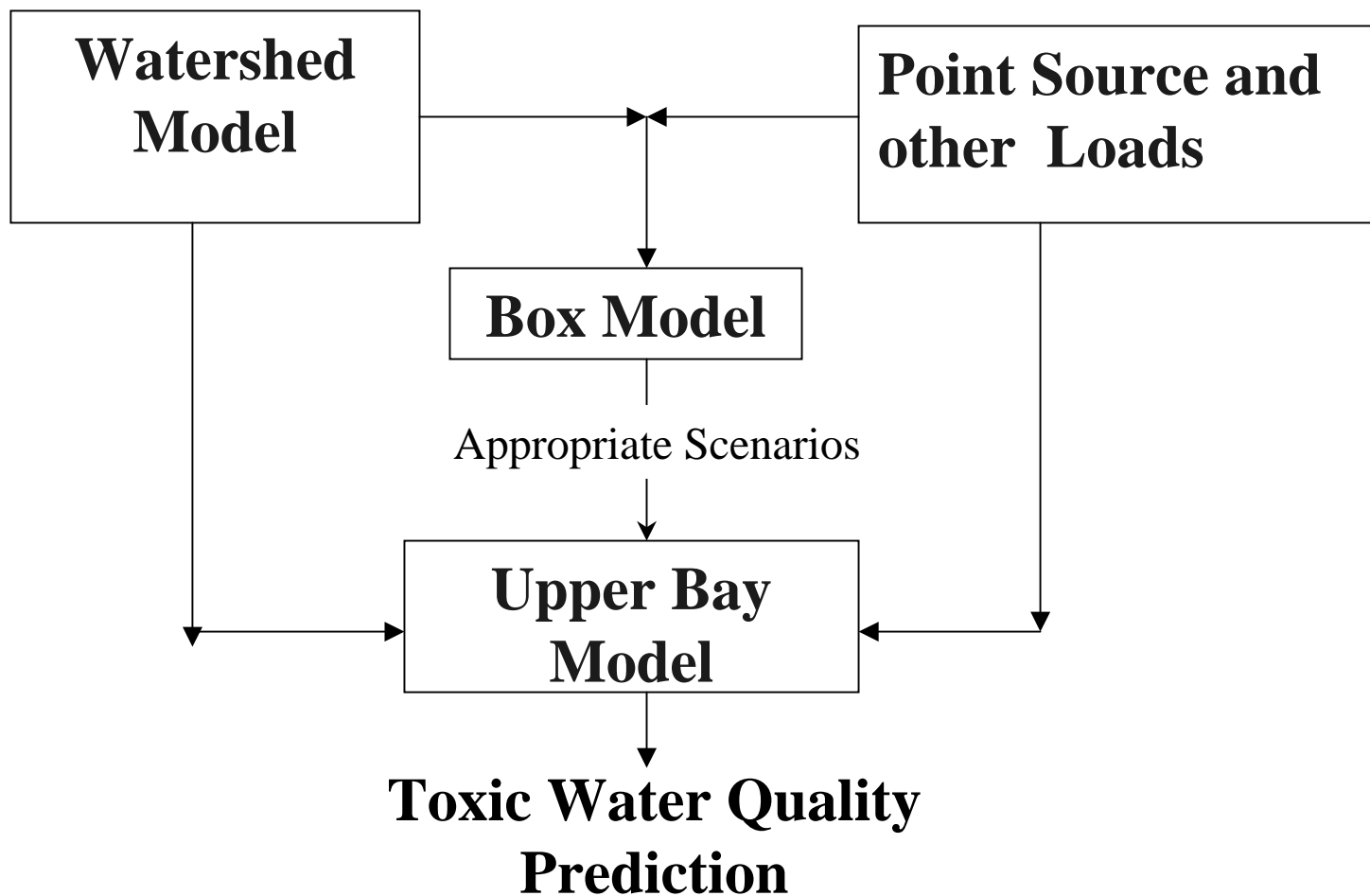
- Models entire Upper Bay to include exchange between the Harbor and the Bay
- Hydrodynamics (water transport) and Sediment Transport
- Toxic (Dissolved/Particulate)



Baltimore Harbor Toxic Impairment



Harbor Toxics Modeling Framework





Toxics – Nonpoint Source Load

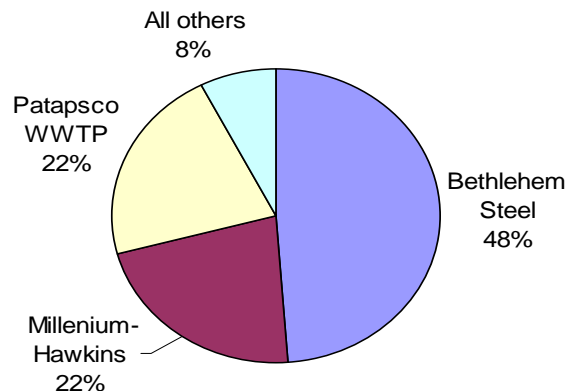
Storm Water Management Model (SWMM)

- Completed : Chromium, Lead, Zinc
 - Internal/External Review Completed
- UNDER DEVELOPMENT : PCB

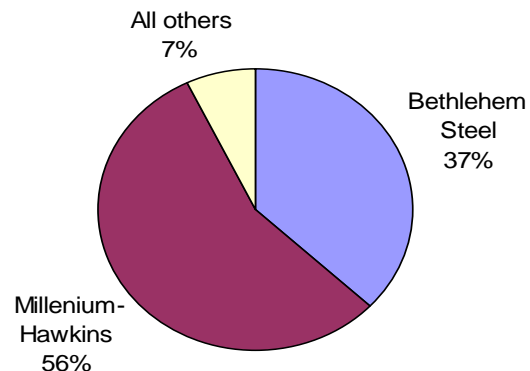
Toxics – Point Source Load

Percent Distribution of Industrial Point Sources

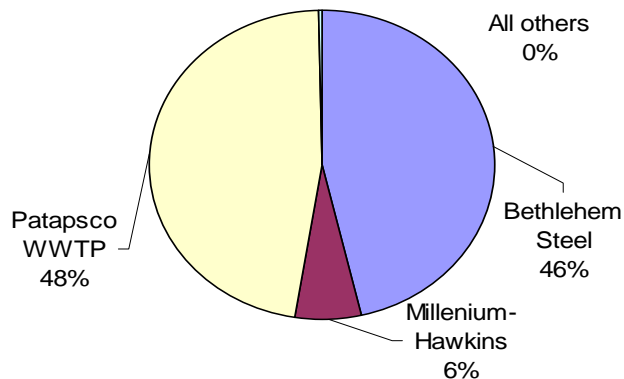
Total Suspended Solids (TSS) Loadings



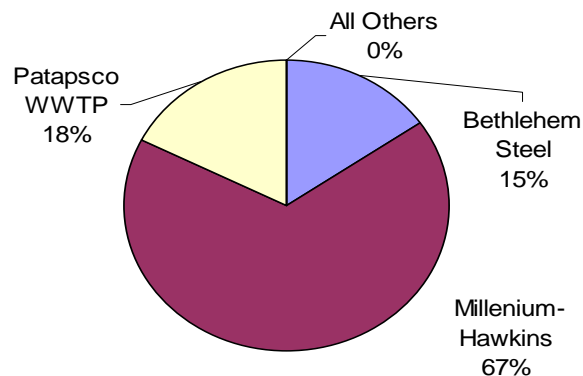
Chromium (Cr) Loadings



Zinc (Zn) Loadings



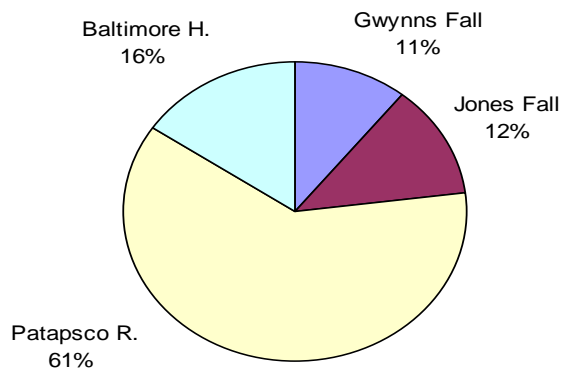
Lead (Pb) Loadings



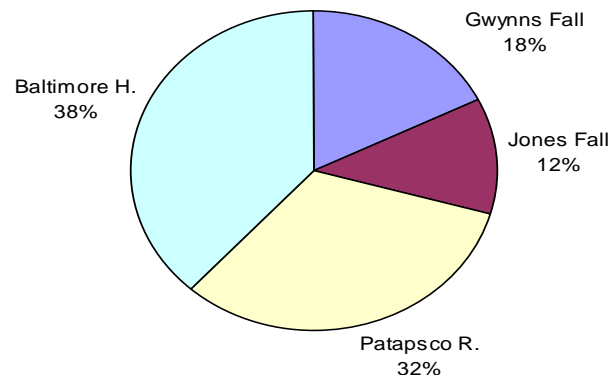
Toxics – Nonpoint Source Load

Percent Distribution of Nonpoint Sources

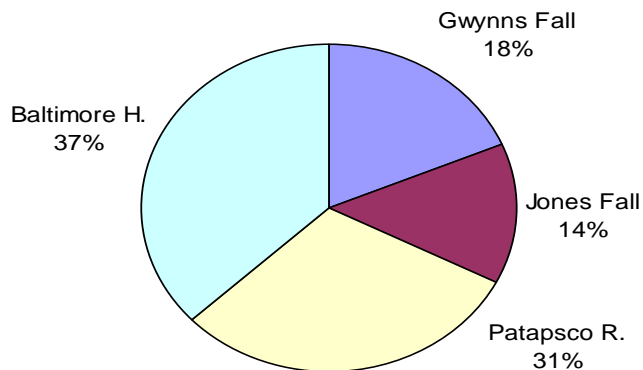
Total Suspended Solids (TSS) Loadings



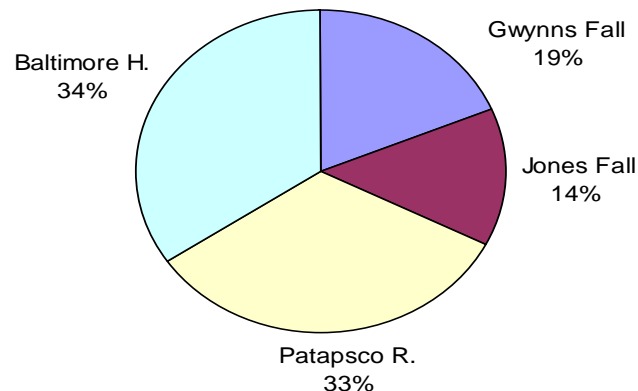
Chromium (Cr) Loadings



Zinc (Zn) Loadings



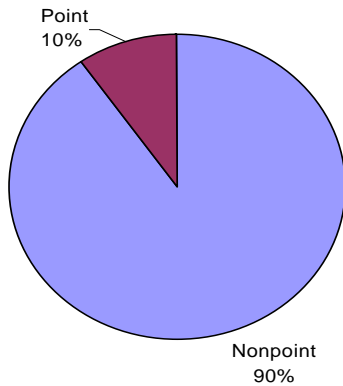
Lead (Pb) Loadings



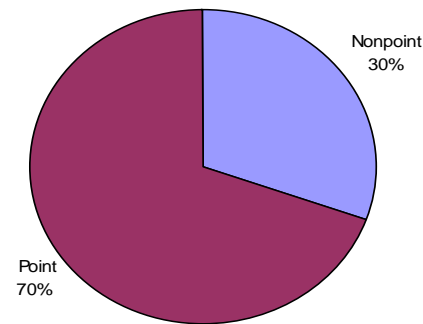
Toxics –

Relative Contributions of Point and Nonpoint Sources

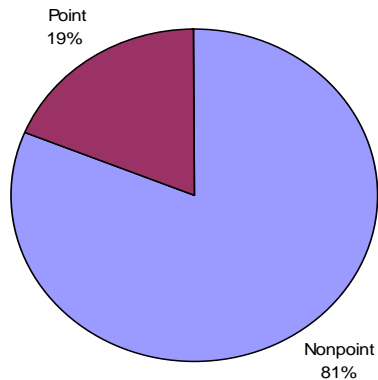
Total Suspended Solids (TSS) Loadings



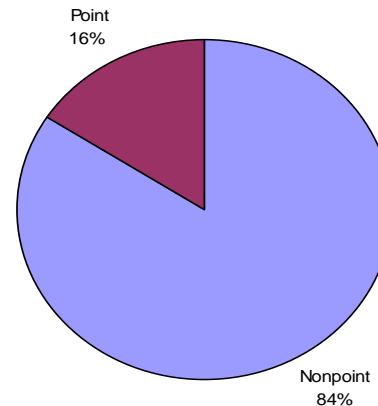
Chromium (Cr) Loadings



Zinc (Zn) Loadings



Lead (Pb) Loadings



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UMCES – Toxic Box Model

- Model Status
 - Hydrodynamic/Sediment Transport
 - Linking Nonpoint Source and Point Source Loads – Completed
 - Mass Balance Check - Completed
 - Transfer Coefficients Calculation - Completed
 - Sediment Transport Sensitivity Test
 - Toxic Box/Foodweb
 - Linking Nonpoint Source and Point Source Loads – Completed
 - Sensitivity Test
 - Linking Hydrodynamic/Sediment Transport Model



Harbor Toxic Modeling Framework

VIMS – Upper Bay Model

- Model Status

- Hydrodynamic/Sediment Transport - Completed
 - Incorporating Nonpoint and Point Sources
- ToxiWasp (simulating fate of toxic) – In Progress
 - Incorporate the numerical Quickest Scheme into the toxic model – Completed
 - Implementation of Toxic Model cell mapping structure - Completed
 - Code testing for sediment toxicant transport - Completed
 - Linkage between hydrodynamic/sediment and toxic models - Completed
 - Incorporating Nonpoint and Point Sources - Completed
 - Calibration
 - Sensitivity analysis

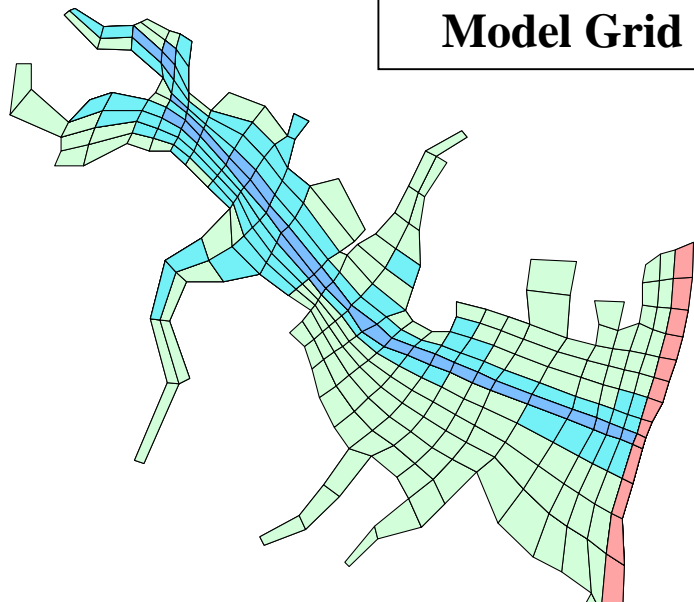


Hydrodynamics and Sediment Transport Model Grid



VIMS Model Domain

ICM/TOXI Model Grid



Baltimore

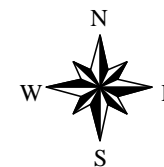
Susquehanna R.

C&D Canal

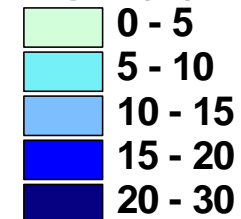
Chester R.

Choptank R.

Open Boundary

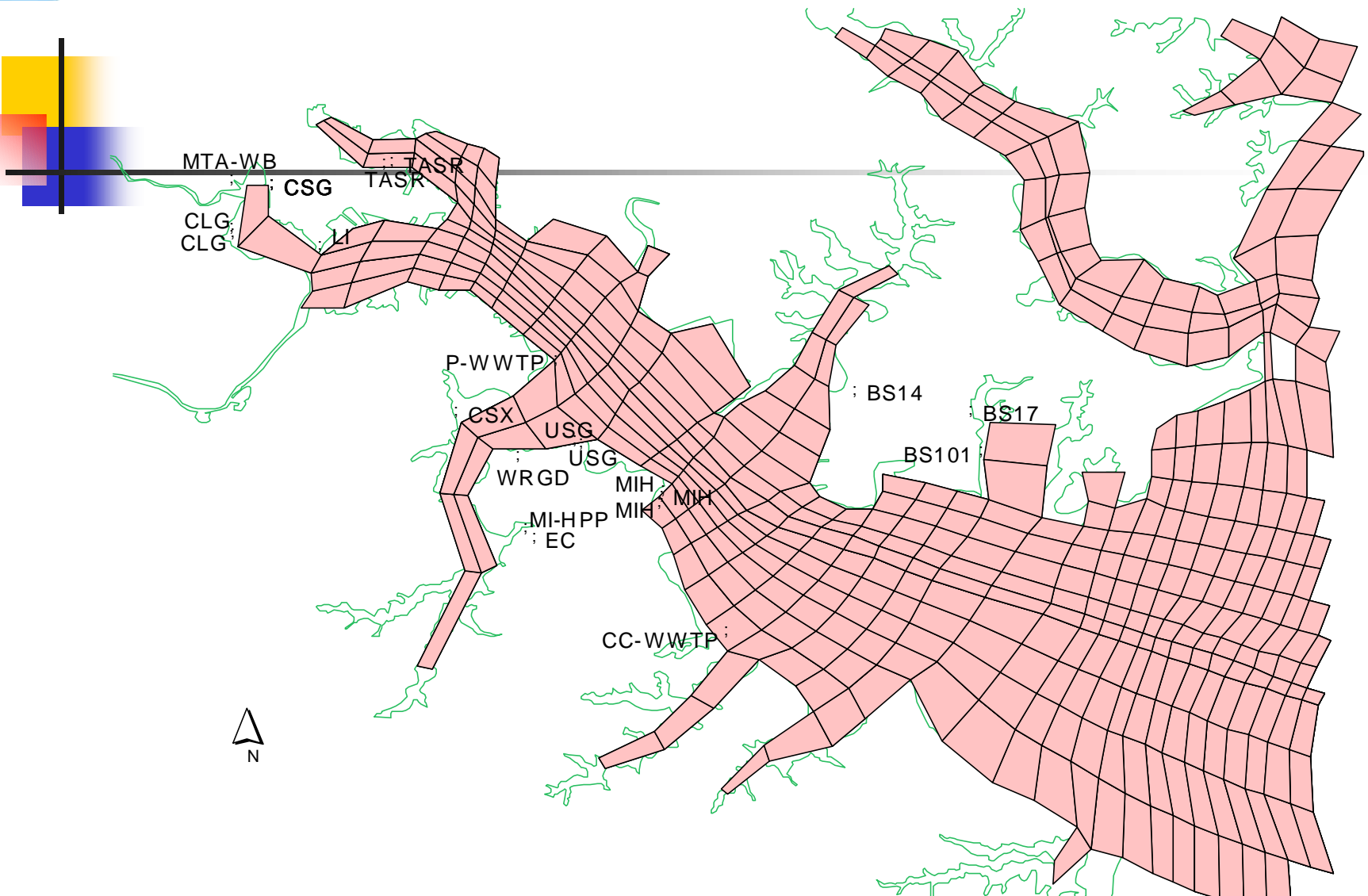


Depth (m)



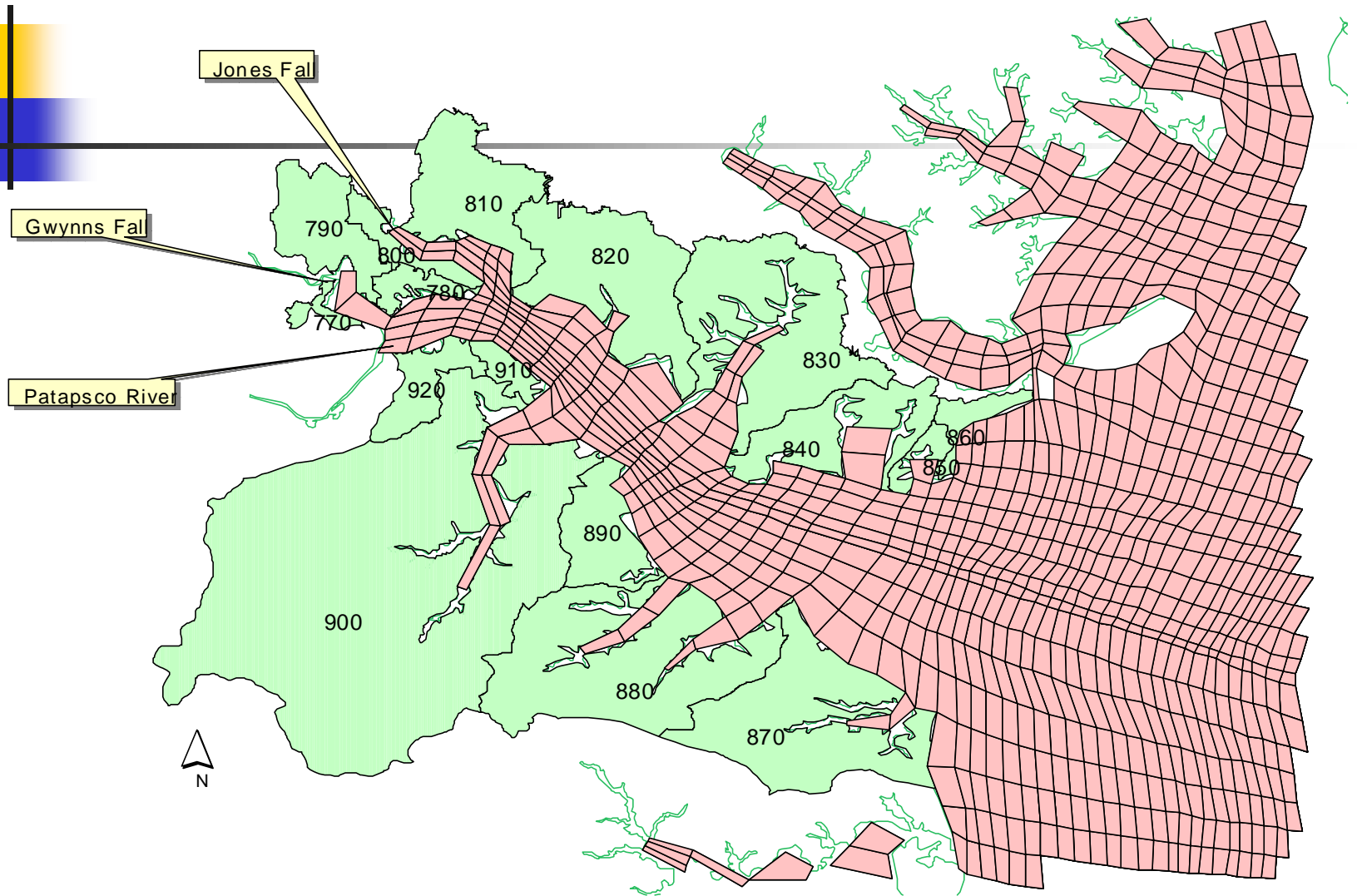


Toxic Point Source Loading to VIMS Model



Note: Point Source loadings from each outfall of the listed industries. They are distributed to the closest model cells.

Toxic Nonpoint Source Loading to VIMS Model

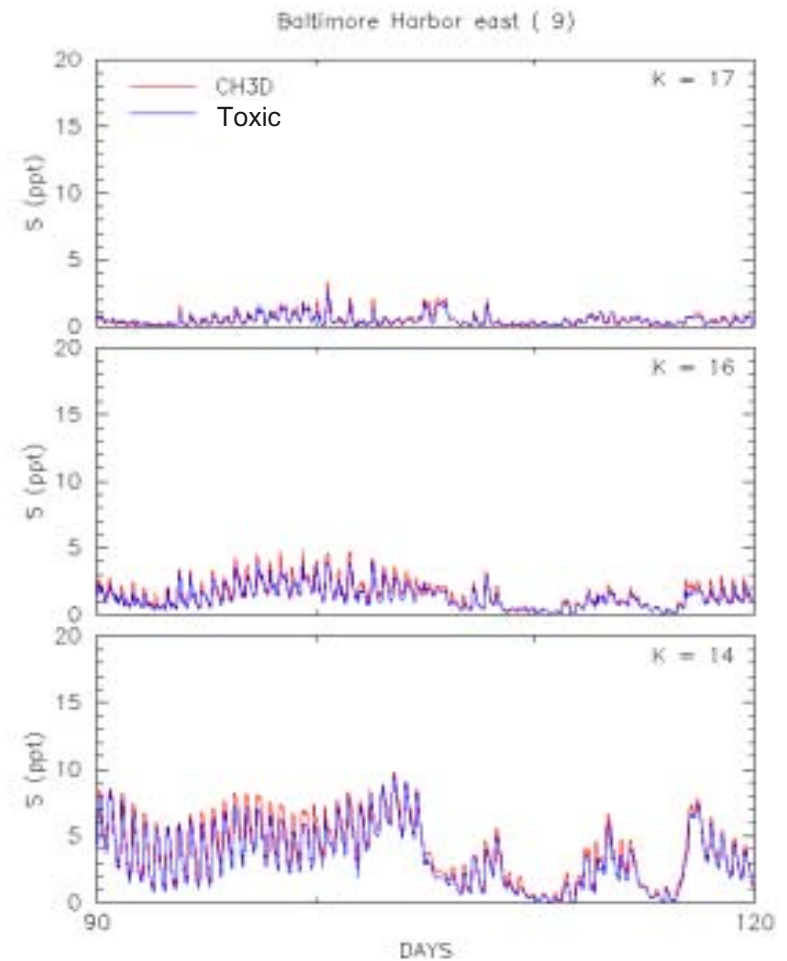
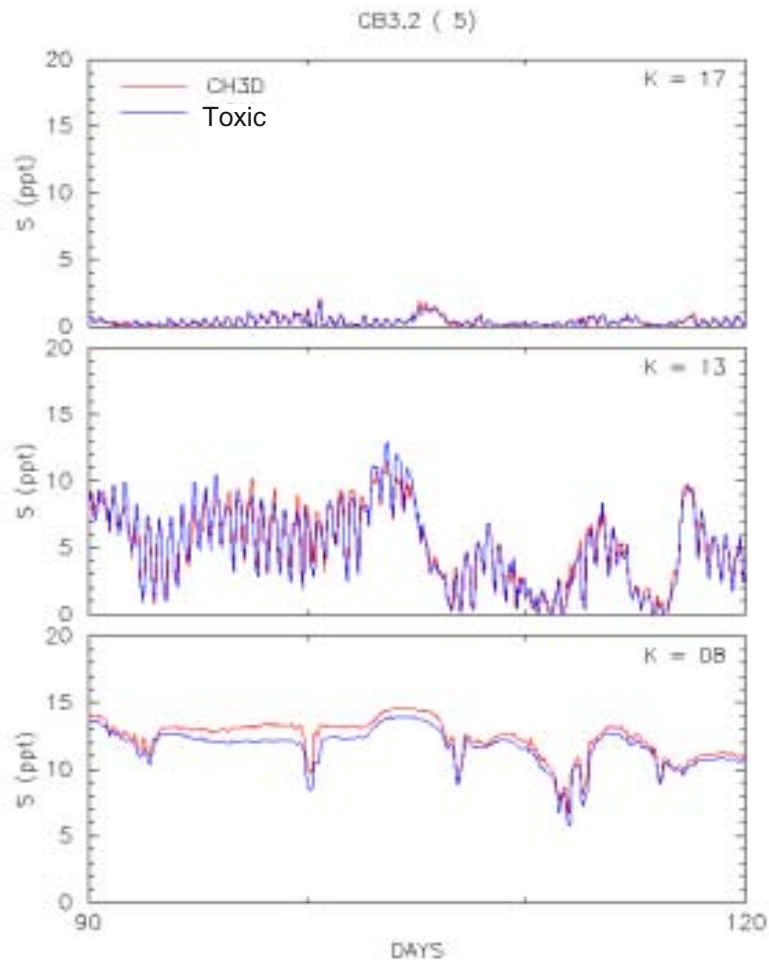


Note: Non-point source loadings from the watershed segments. They are evenly distributed to their adjacent model cells.

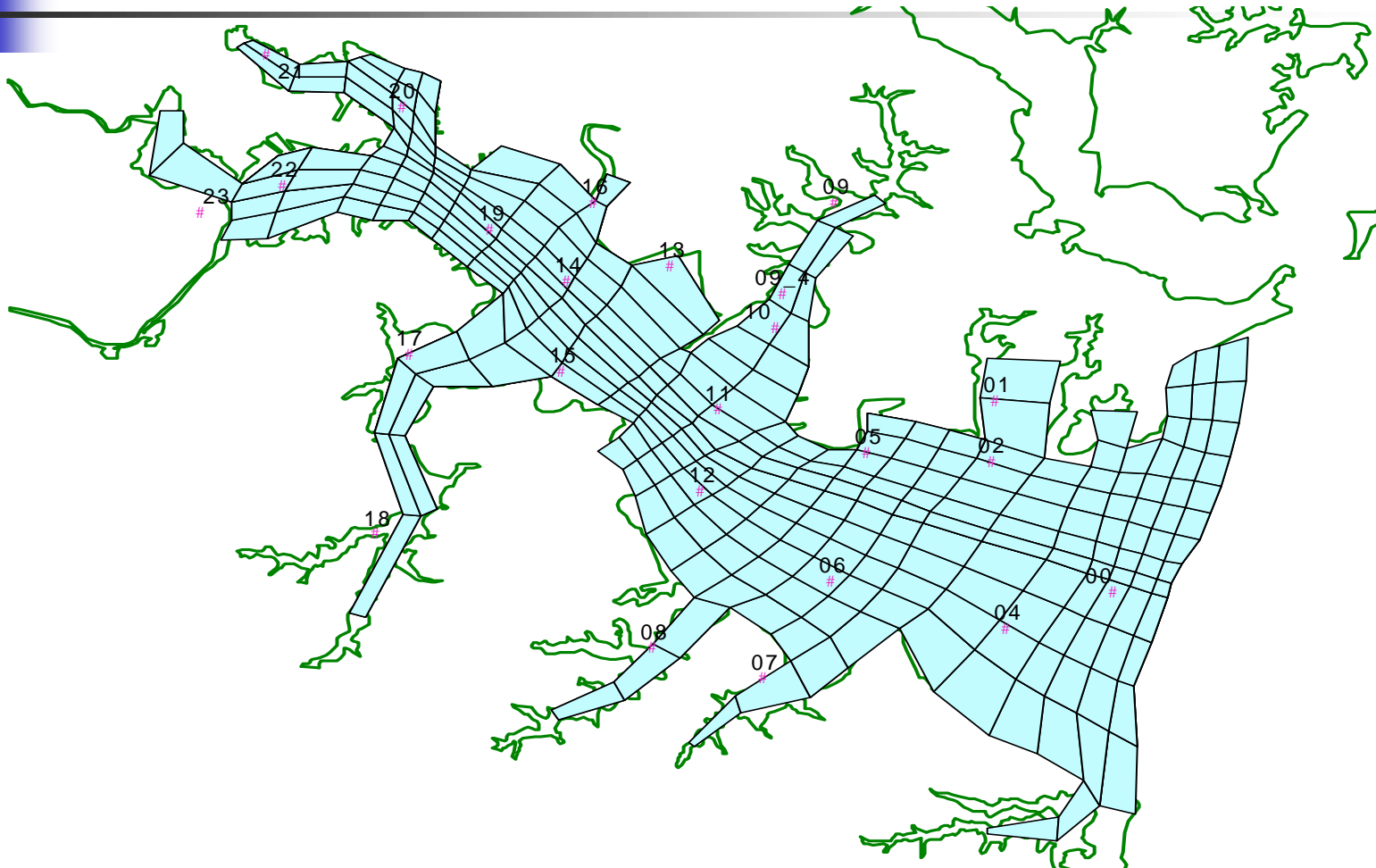


Harbor Toxic Modeling Framework

VIMS –Hydrodynamic/Sediment Model Calibration stations

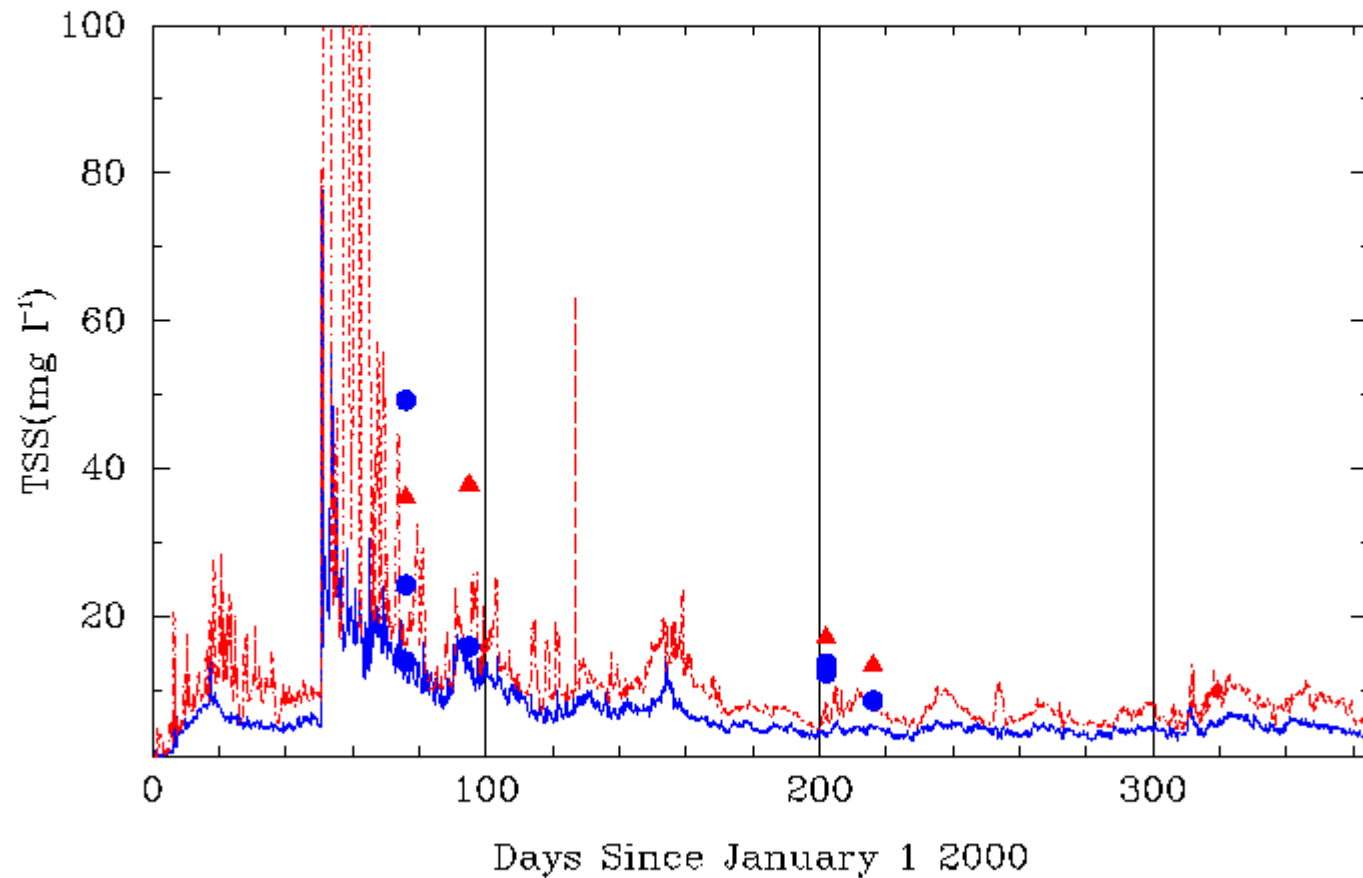


Harbor Sampling Stations



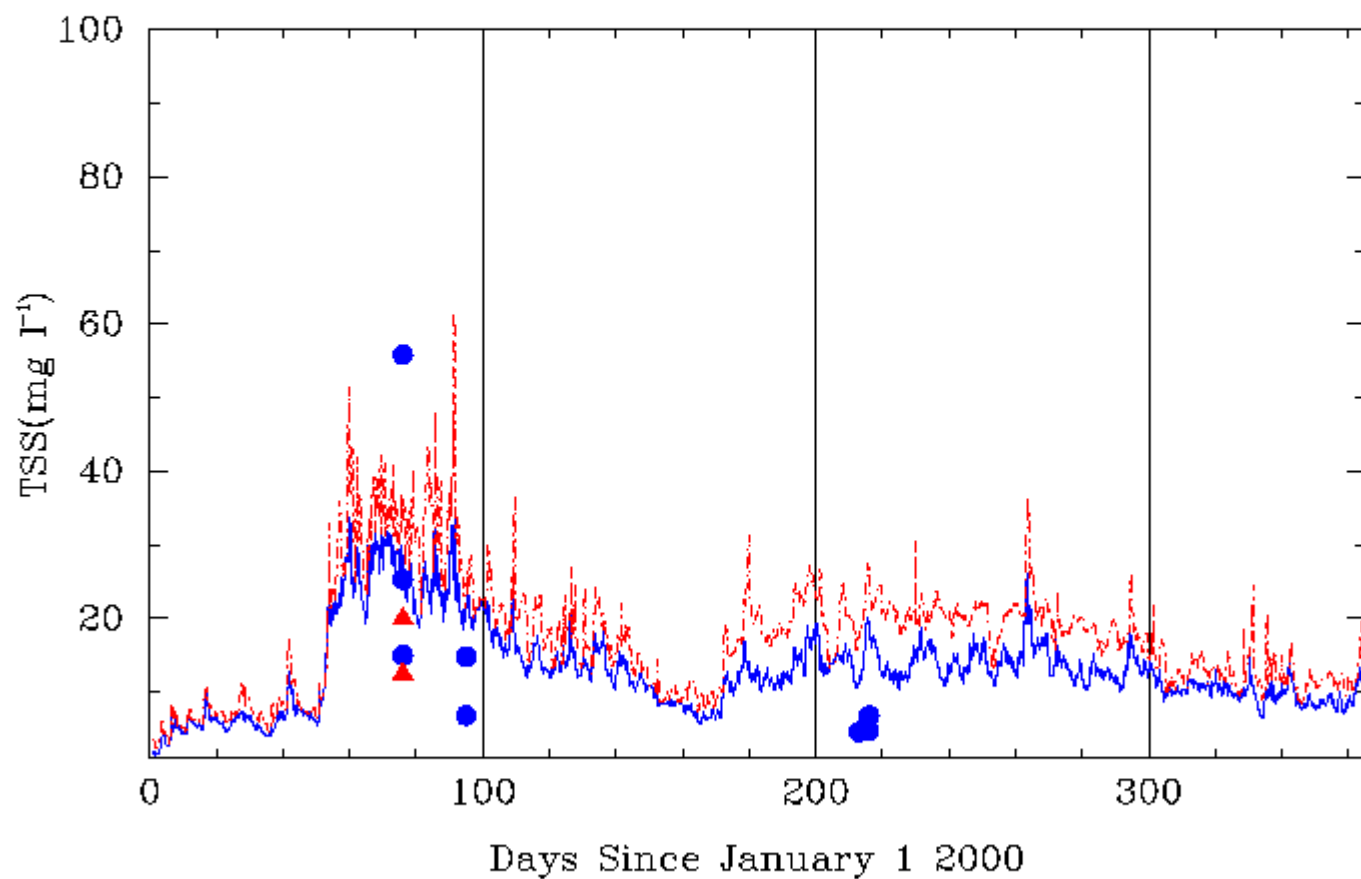
TSS Calibration - Harbor Mouth

00



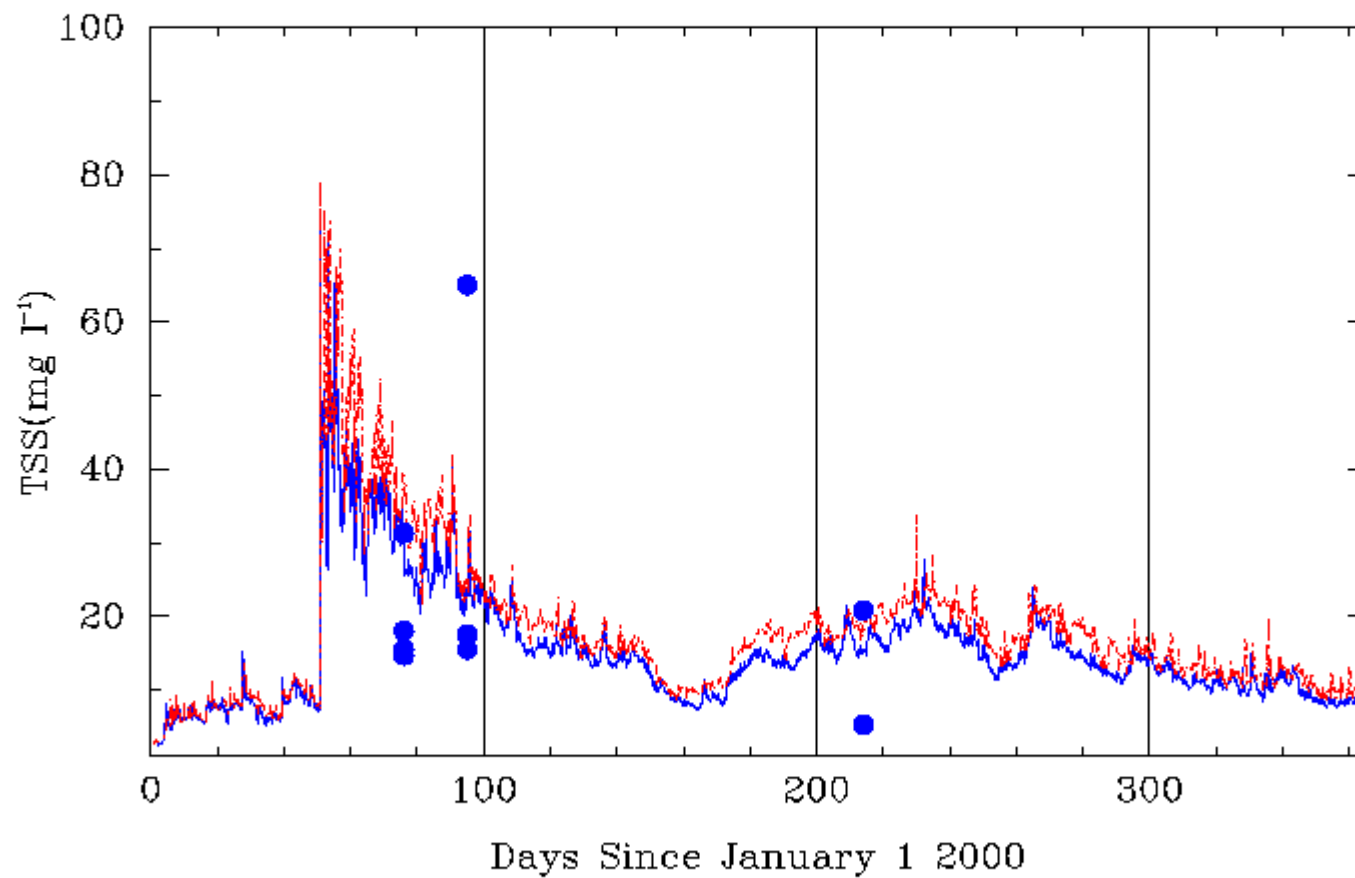
TSS Calibration - Inner NW Branch

21



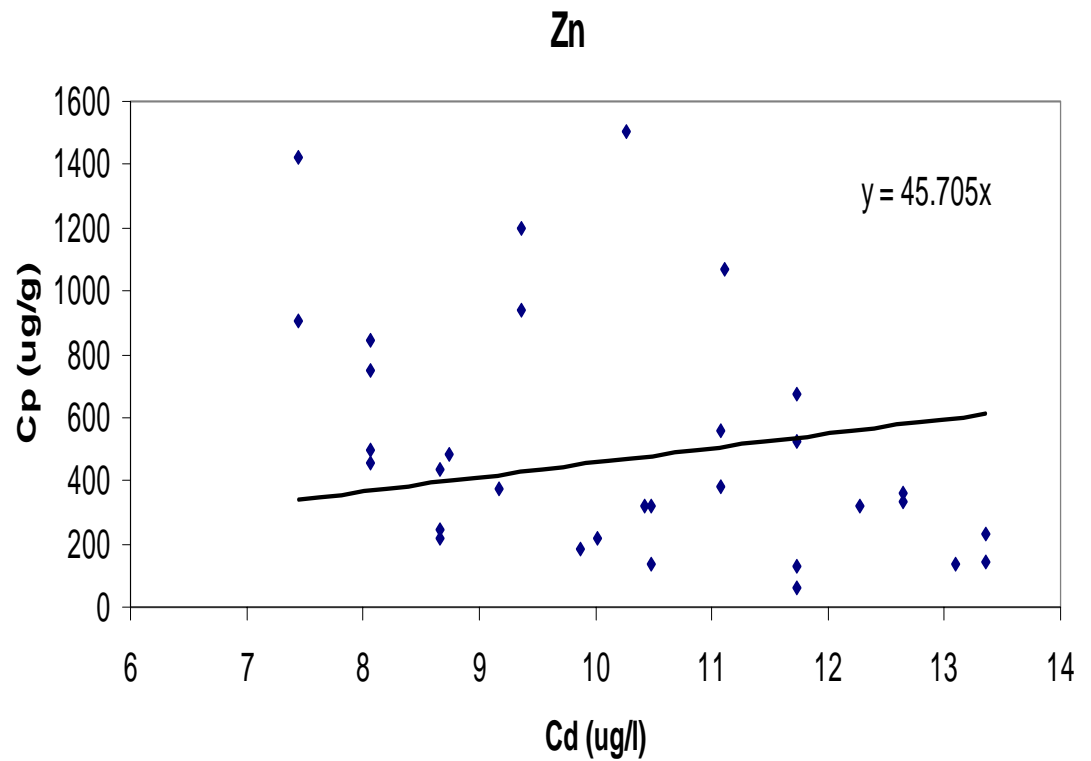
TSS Calibration - Middle Branch

22

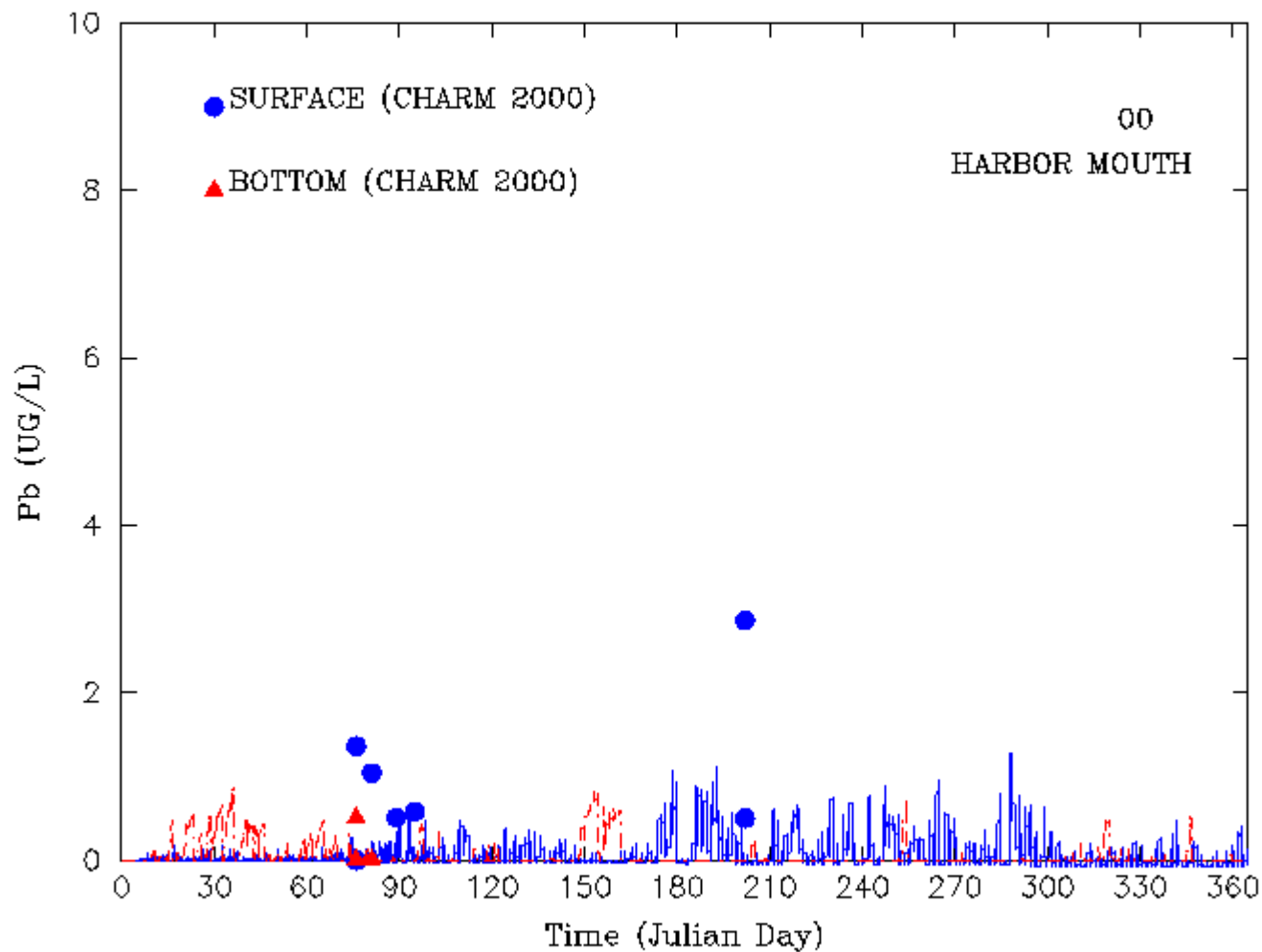


Metal Calibration

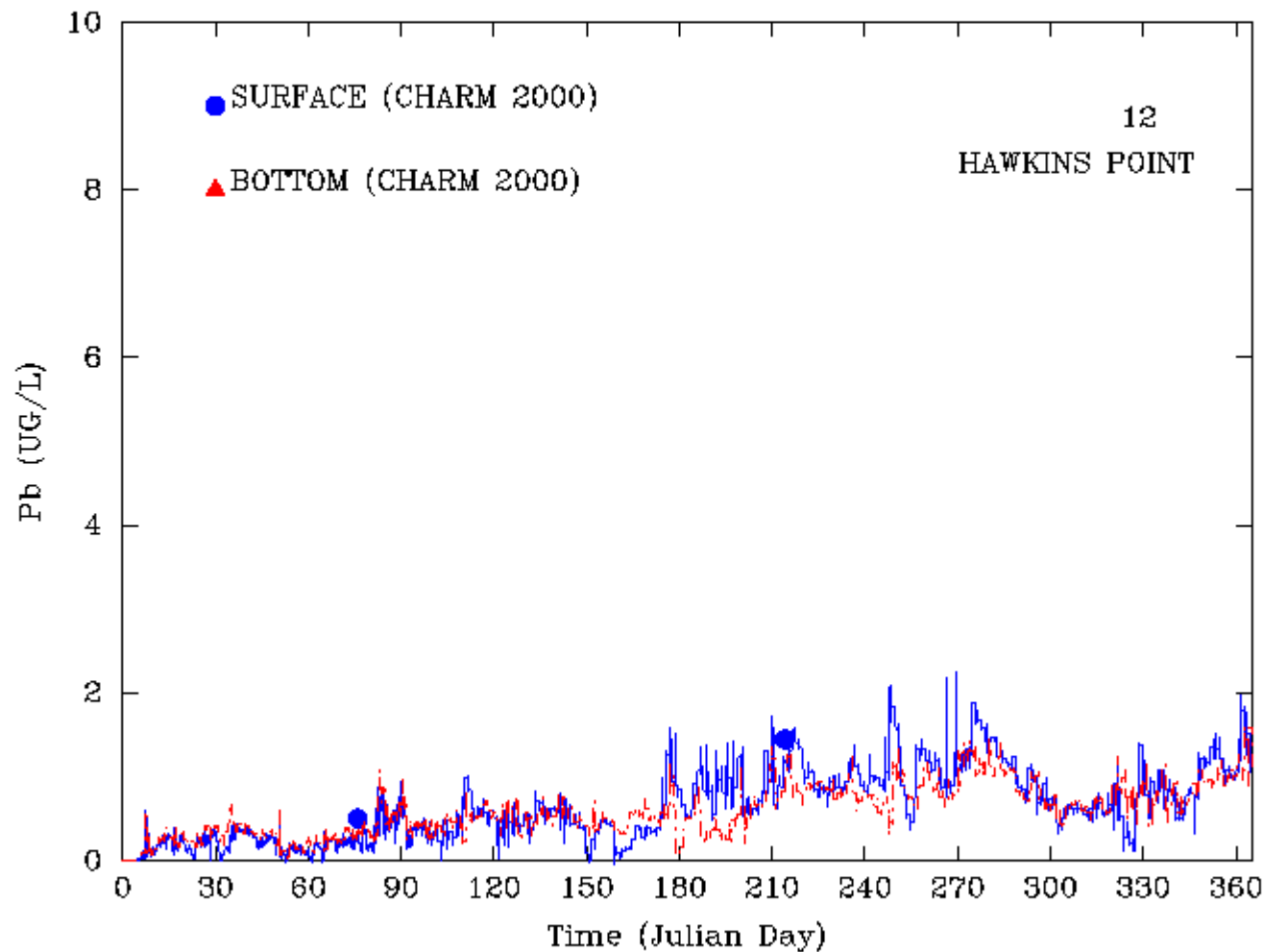
Metal	Partition Coefficient (10^4 l/kg)
Pb	5.9
Zn	4.6
Cr	21.7



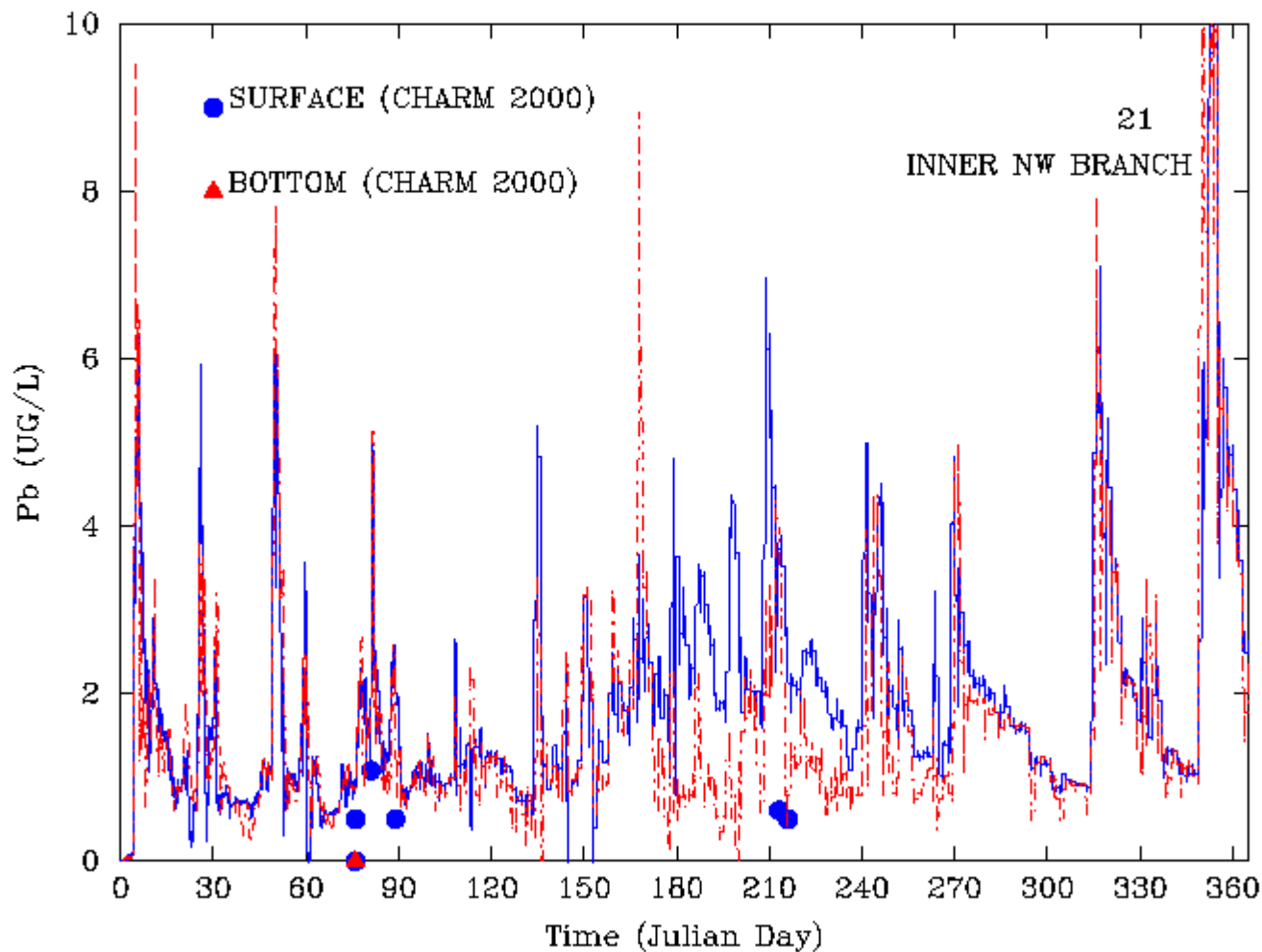
Pb Calibration - Harbor Mouth



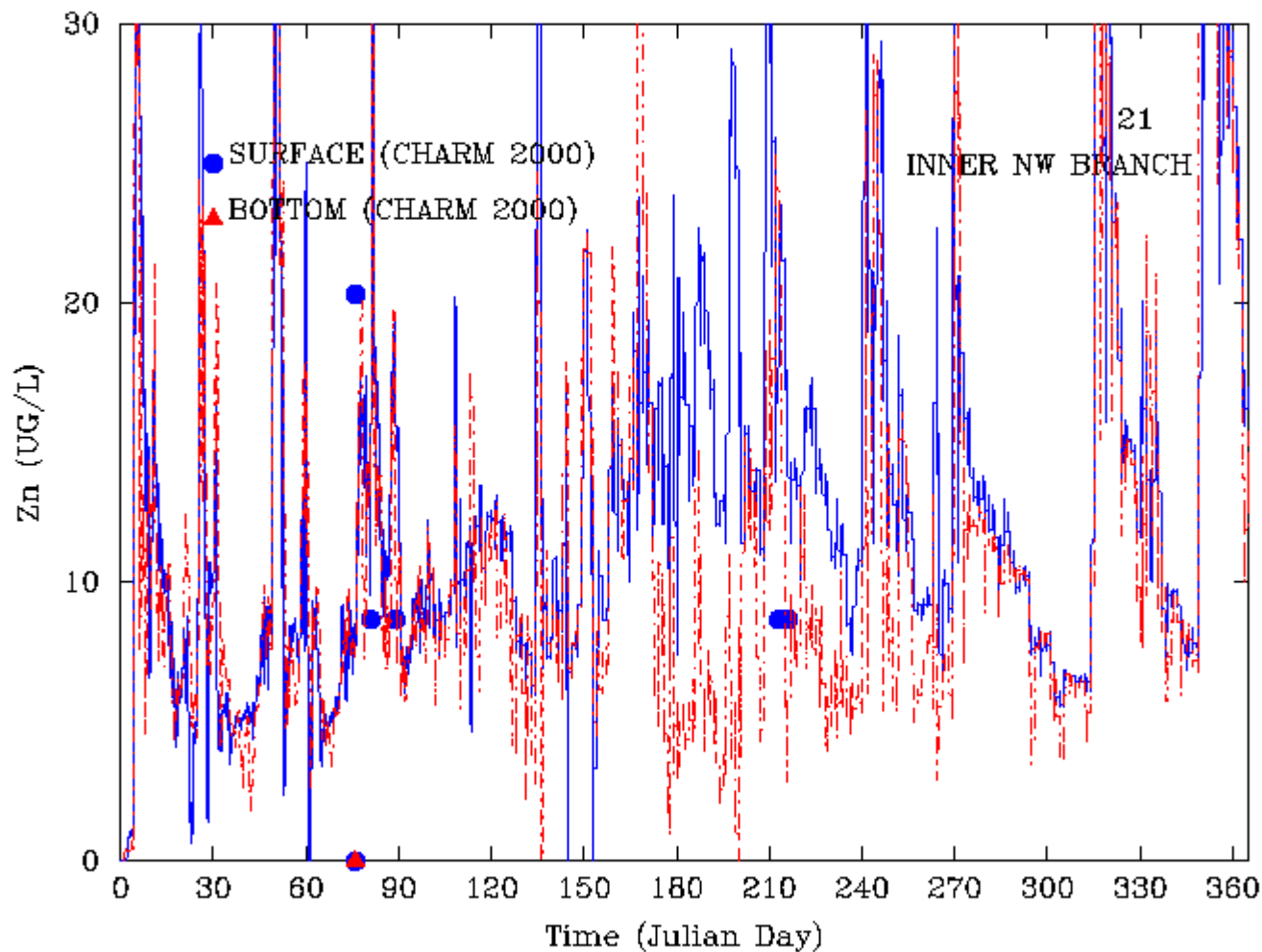
Pb Calibration - Hawkins Point



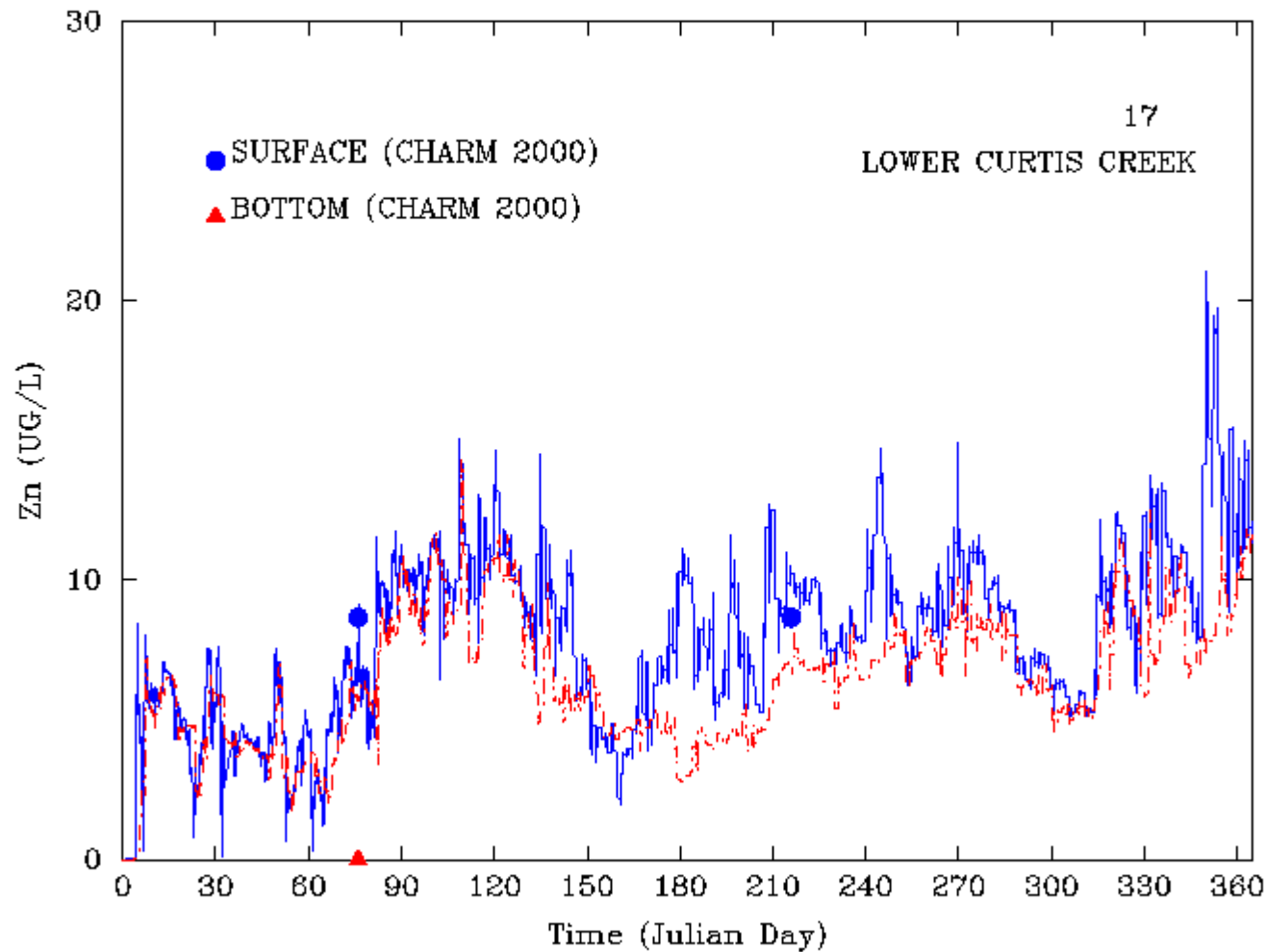
Pb Calibration - Inner Harbor



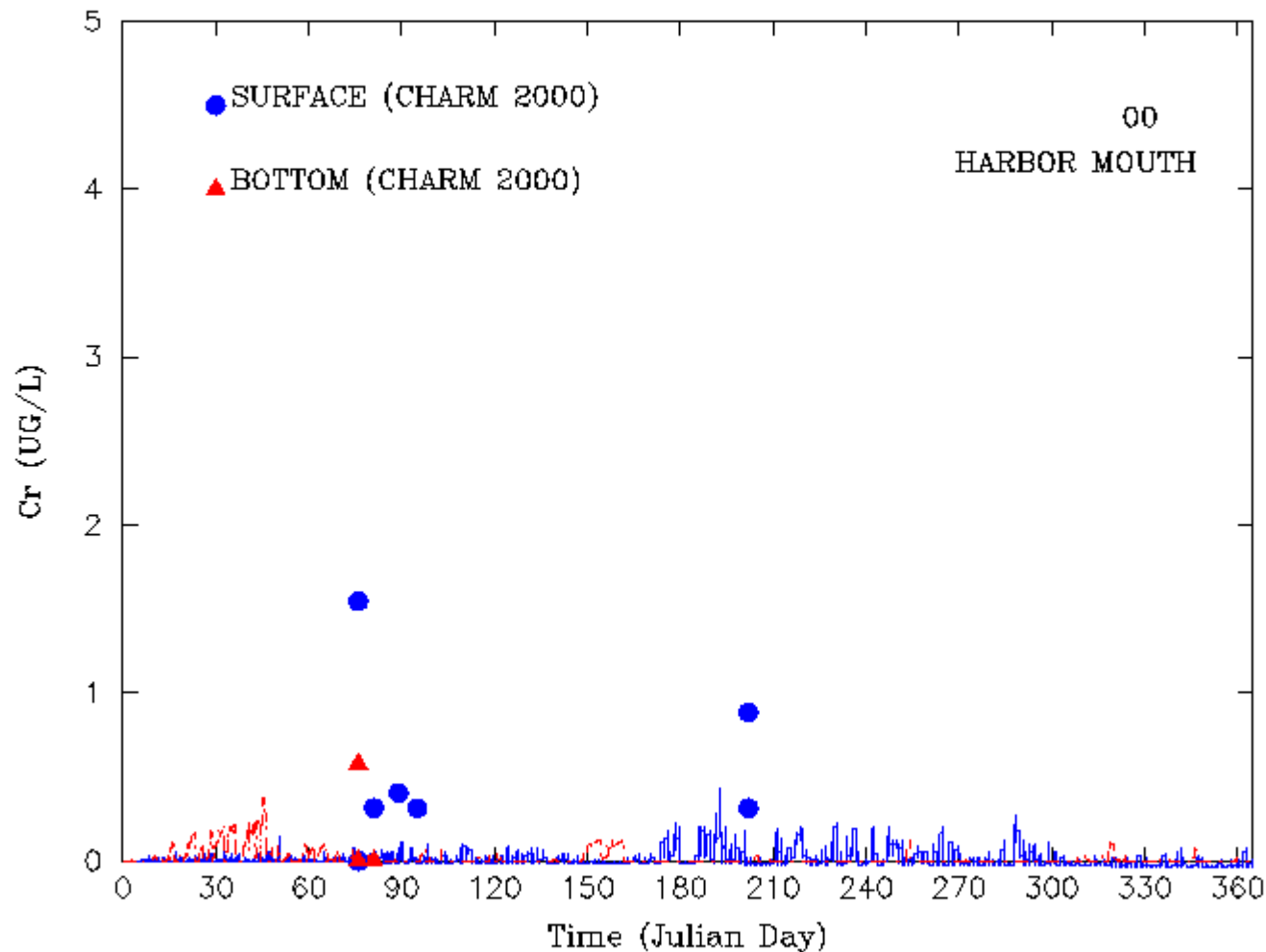
Zn Calibration - Inner Harbor



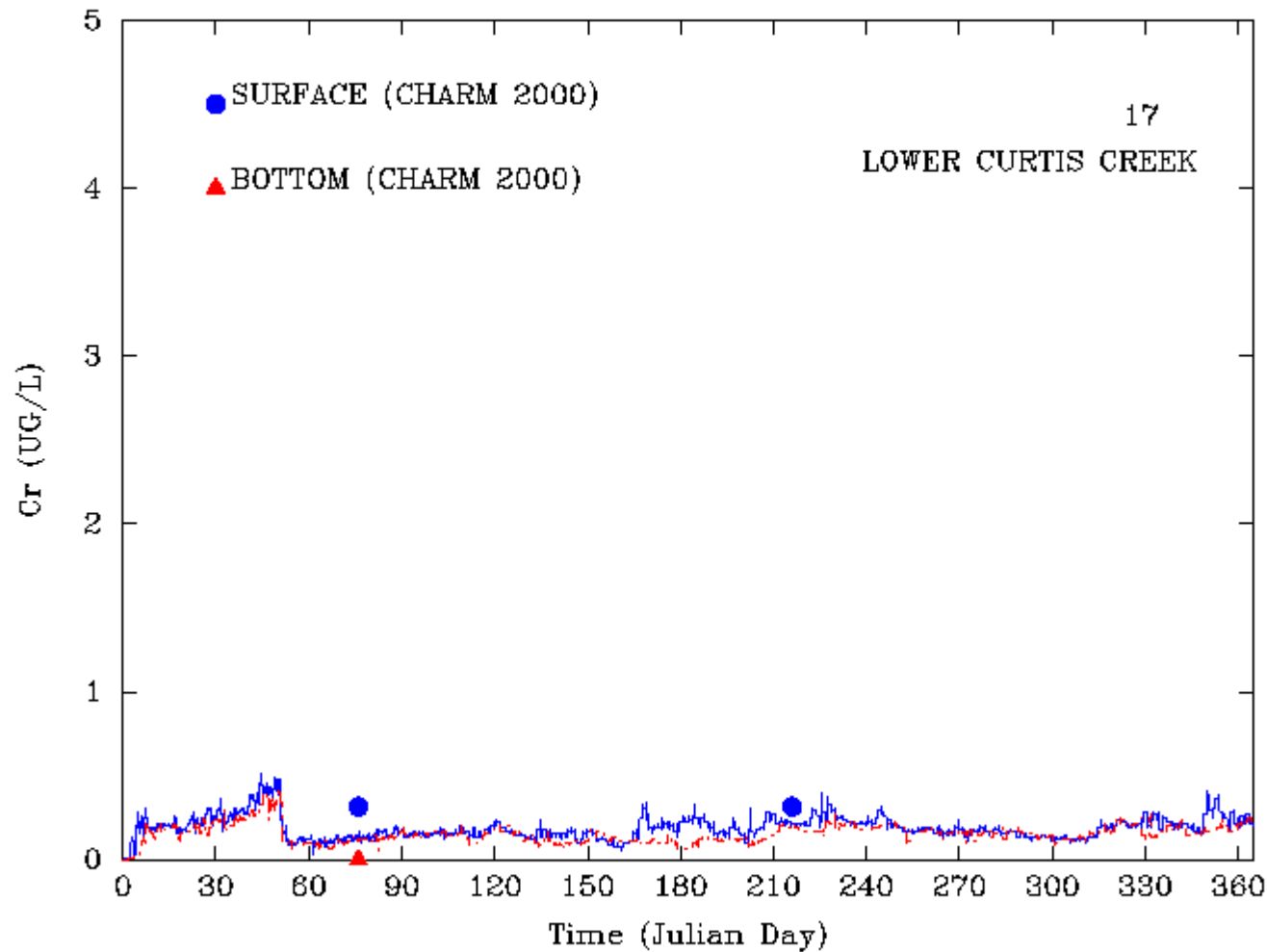
Zn Calibration - Lower Curtis Creek



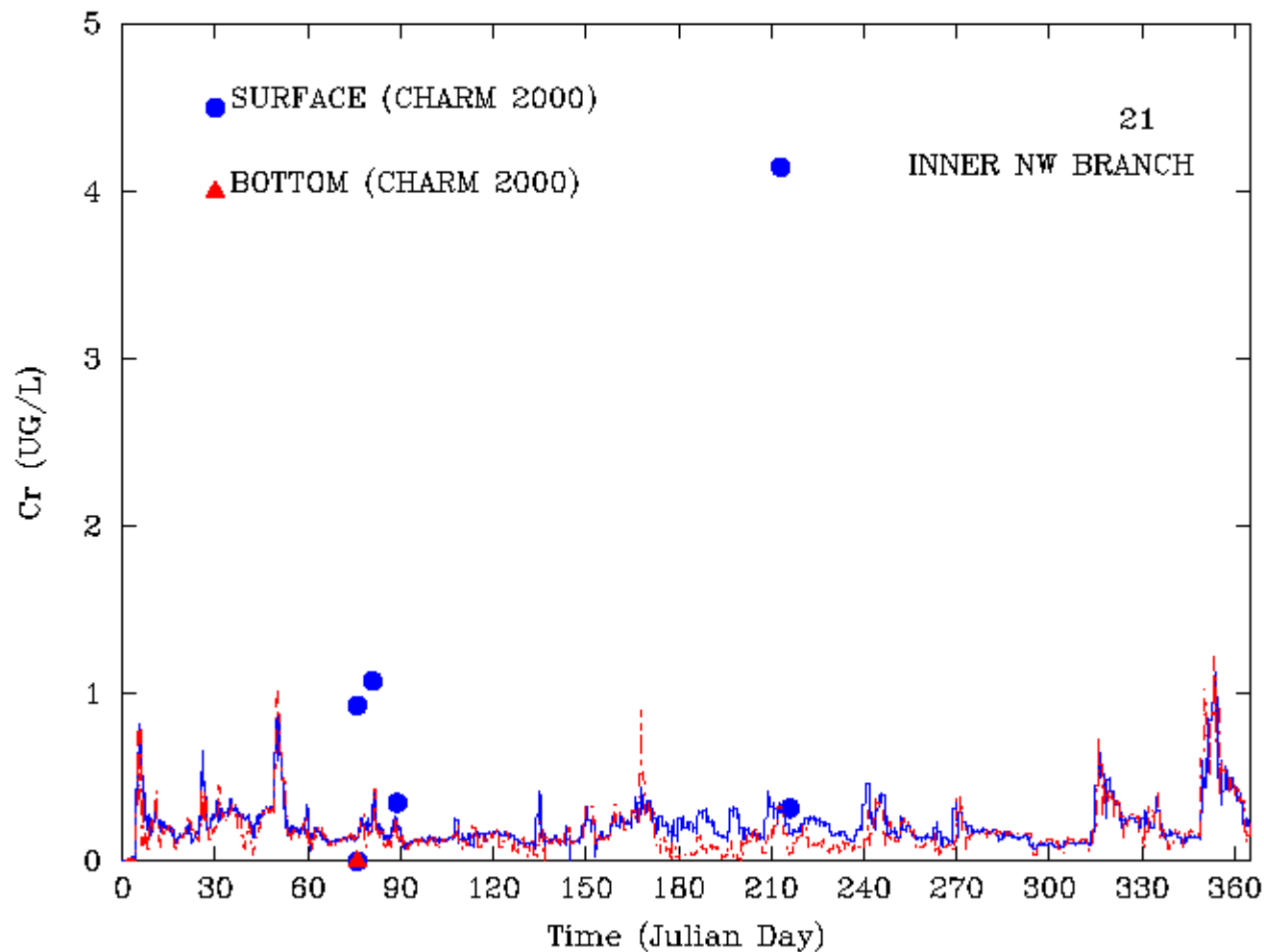
Cr Calibration - Harbor Mouth



Cr Calibration - Lower Curtis Creek



Cr Calibration - Inner Harbor



VIMS Toxic Modeling - Summary

- The simulation of TSS, Pb, Zn, and Cr for 2000 has been performed.
- The TSS simulation results appear reasonable throughout the model domain.
- Pb and Zn are well-predicted in the middle and lower Harbor, but over-predicted in Inner Harbor.
- Cr is well-predicted in Inner Harbor and under-predicted in the lower Harbor.



Harbor Toxic TMDLs: Progress/Future Actions

Progress to Date

- Point Source Loads
- Nonpoint Source Loads (SWMM)
- UMCES Harbor Hydrodynamic/Sediment Transport Model
- VIMS Upper Bay Hydrodynamic/Sediment Transport Model

Future Actions

- UMCES Harbor Box Model
- VIMS Harbor Toxic Model for Metals
- Model Sensitivity Tests
- Scenarios

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Harbor Eutrophication Modeling Program

- **Estimate Nonpoint Source Loads - Watershed Modeling**
 - Hydrologic Simulation Program Fortran (HSPF) - **Completed**

- **Simulate Water Quality in Baltimore Harbor – Harbor Modeling – Final Stage**
 - A 3-D **Hydrodynamic** Model - Curvilinear Hydrodynamic 3-Dimension (CH3D)
 - A 3-D Comprehensive **Water Quality** Model - CE-QUAL-ICM
 - A **Sediment** Diagenesis Model

A decorative graphic consisting of overlapping yellow, red, and blue squares with a black crosshair is positioned to the left of the title.

Current Eutrophication Model Status

- Watershed (HSPF) – Completed
(Internal/External Review Completed)
- Hydrodynamic Model – Completed
- Water Quality Model – Refine Calibration

A decorative graphic consisting of overlapping yellow, red, and blue squares with a black crosshair is positioned to the left of the title.

Eutrophication Model - Calibration

Problems:

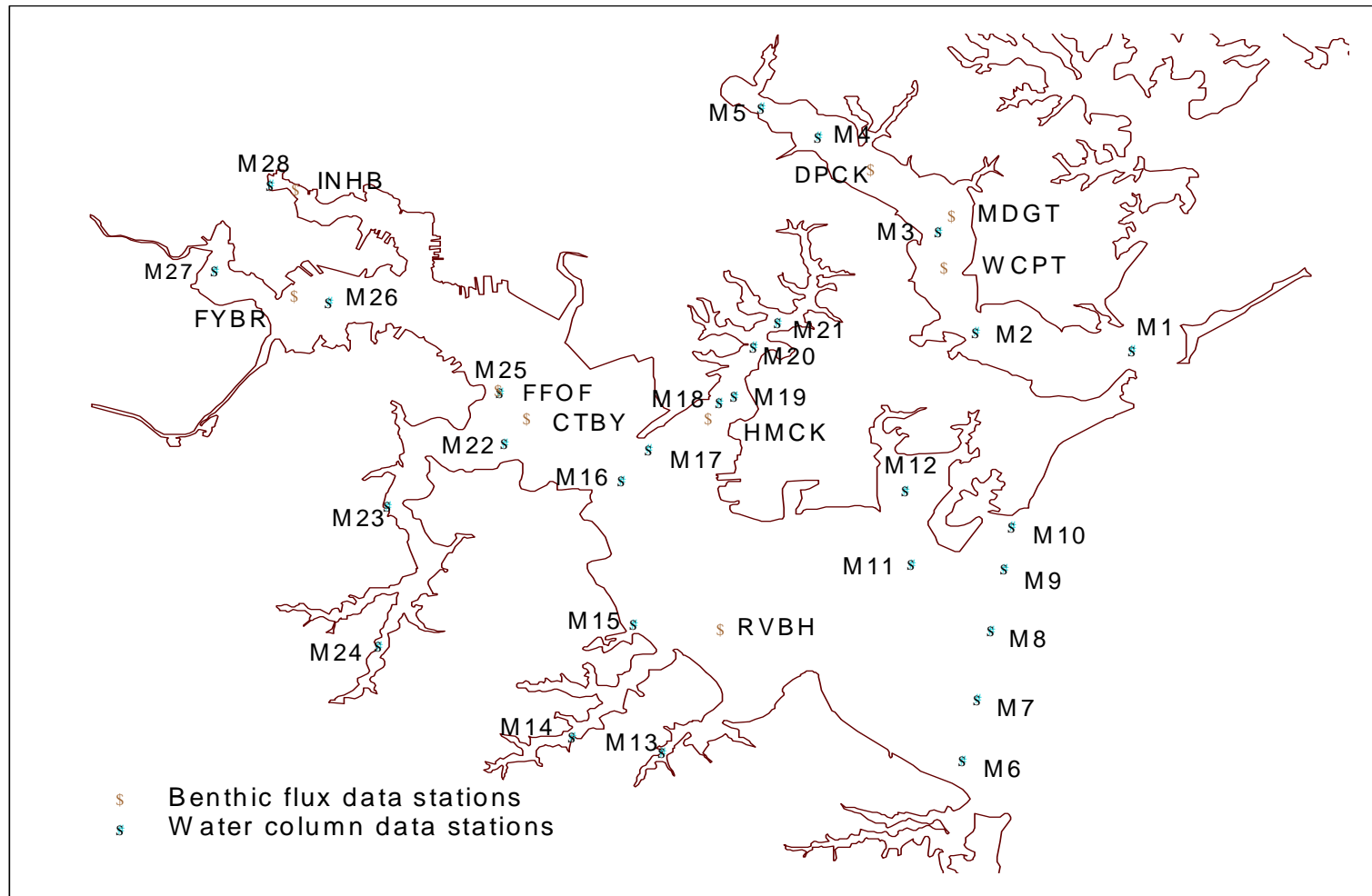
- Overestimate DO concentration (End point = 5 mg/L)
- Underestimate Chlorophyll a concentration (End point = 50 ug/L)

Hypotheses/Tests:

- DO issue
 - The occurring of hypoxia is sensitive to the water depth
- Chlorophyll issue
 - Resuspension
 - Sediment initial concentration
 - Zooplankton grazing rate

Eutrophication Model – Calibration

Sampling Stations





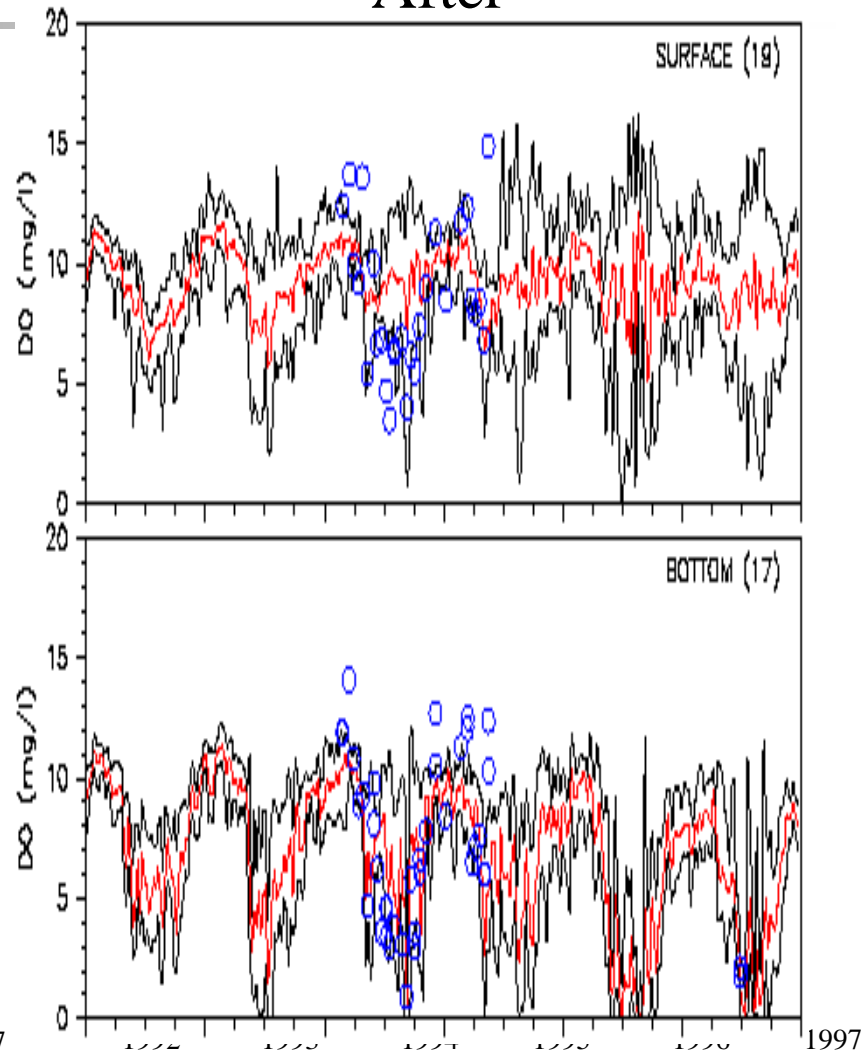
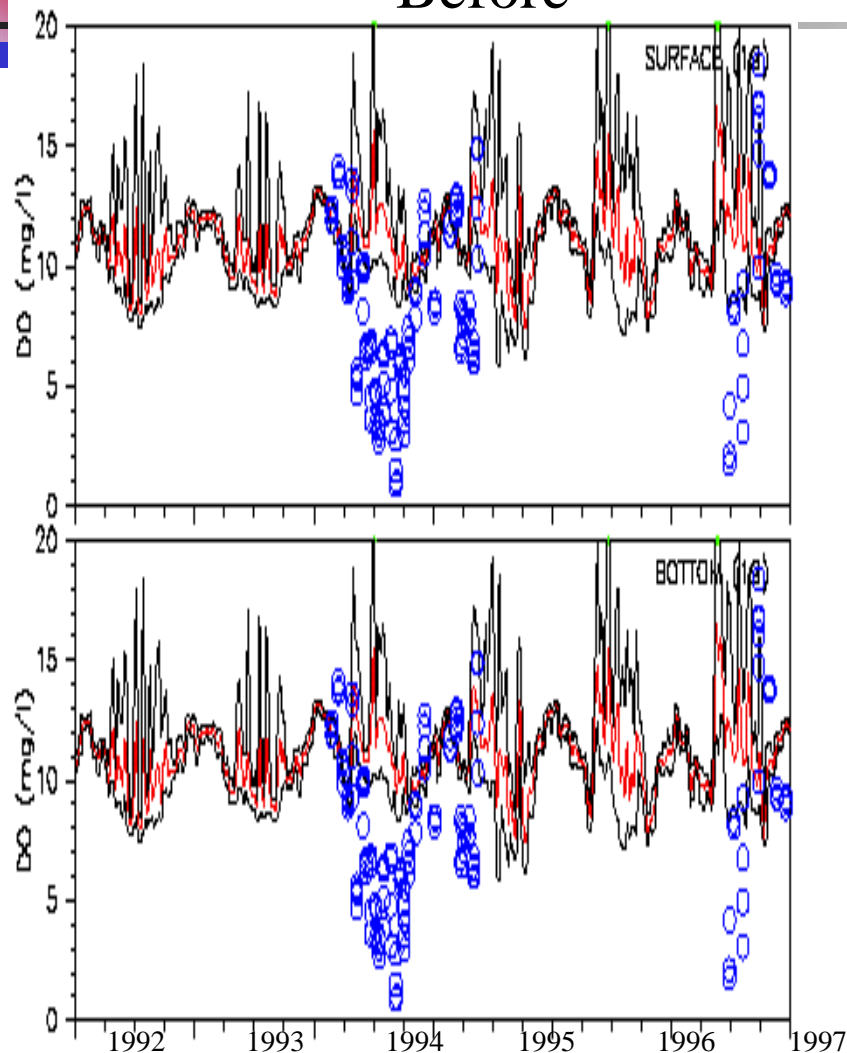
Eutrophication Model – Calibration

DO vs. Water Depth

Middle Branch

Before

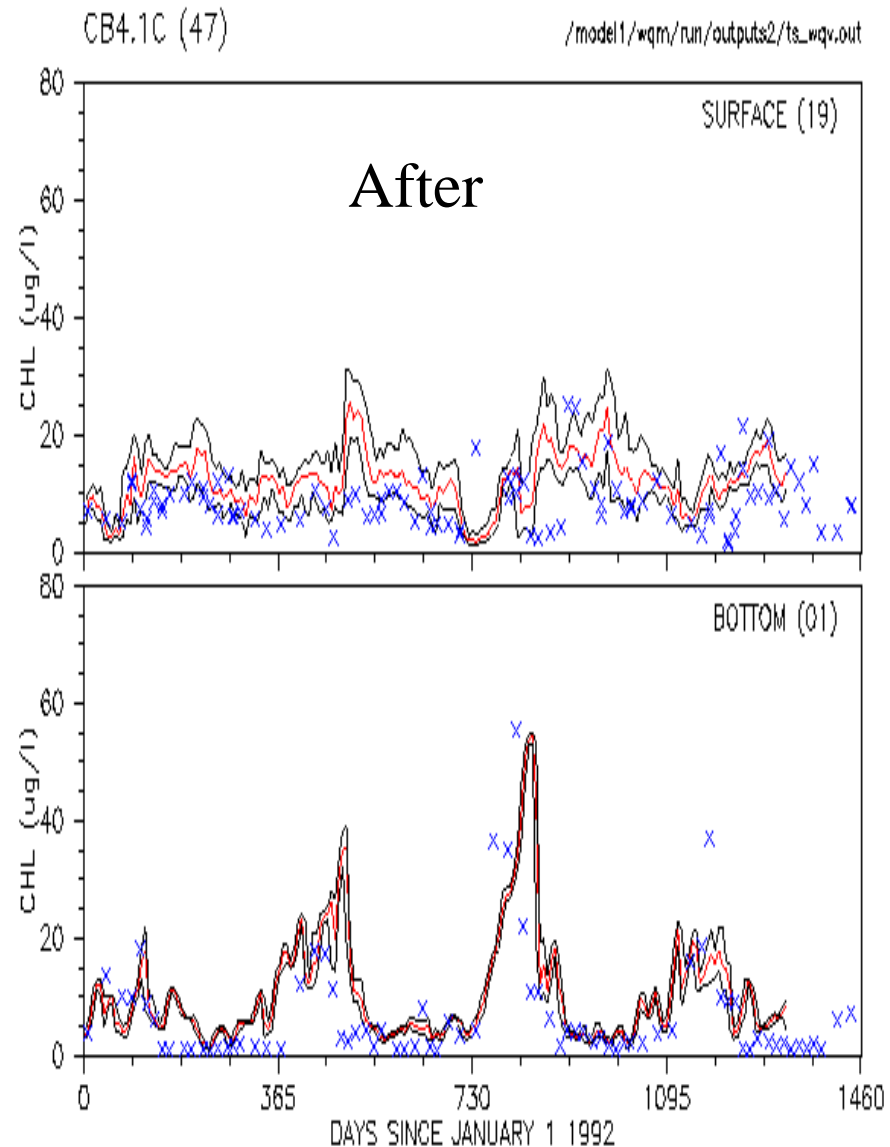
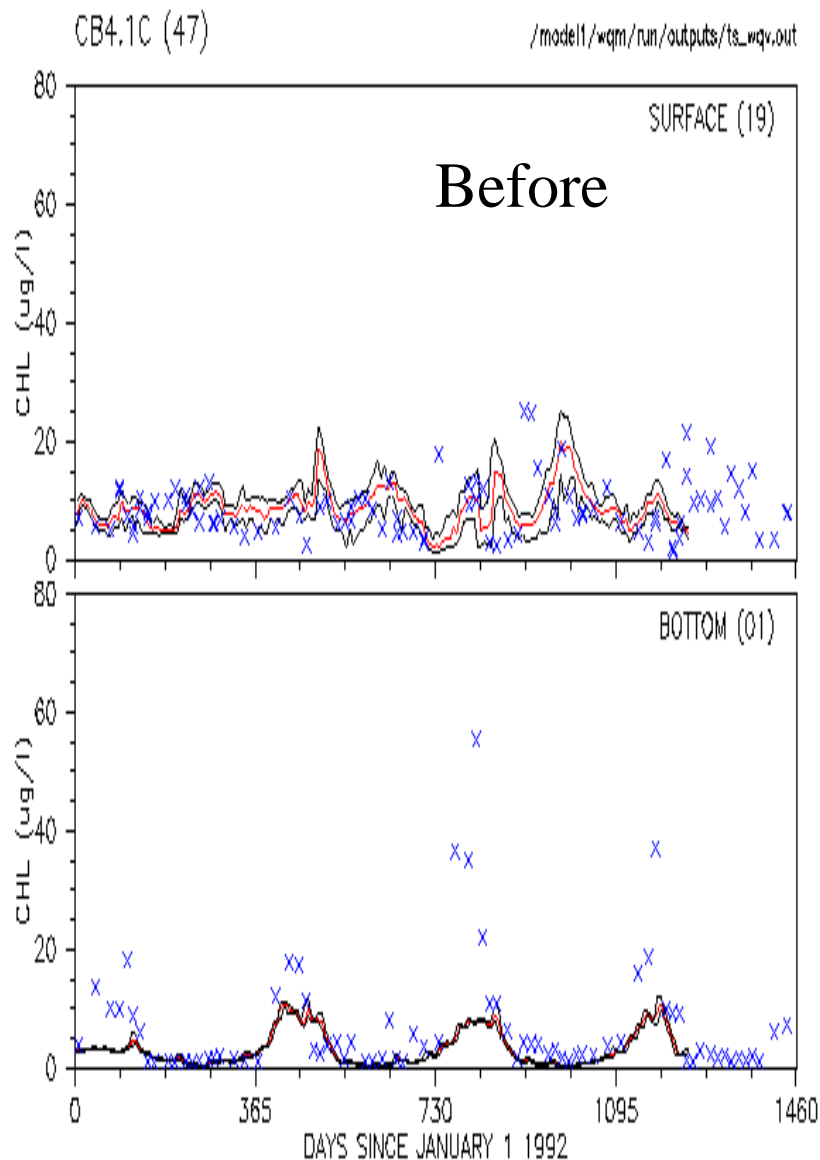
After





Eutrophication Model – Calibration

Chla vs. Resuspension

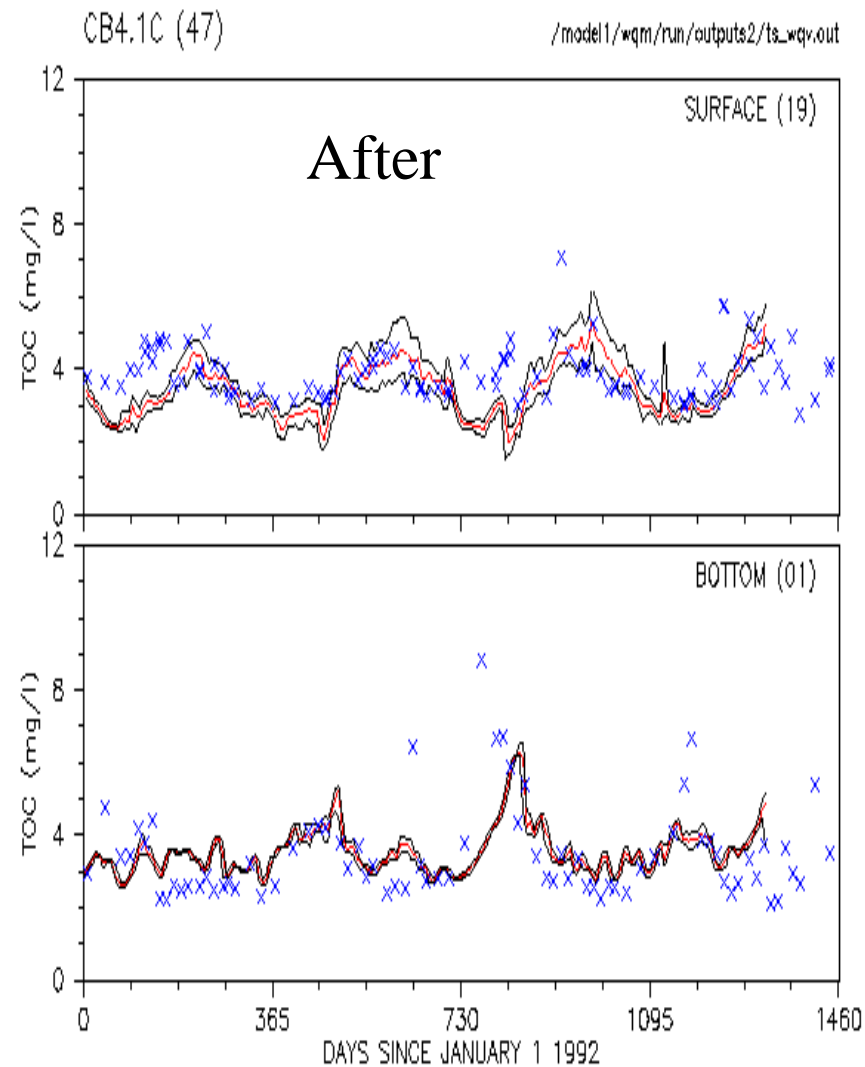
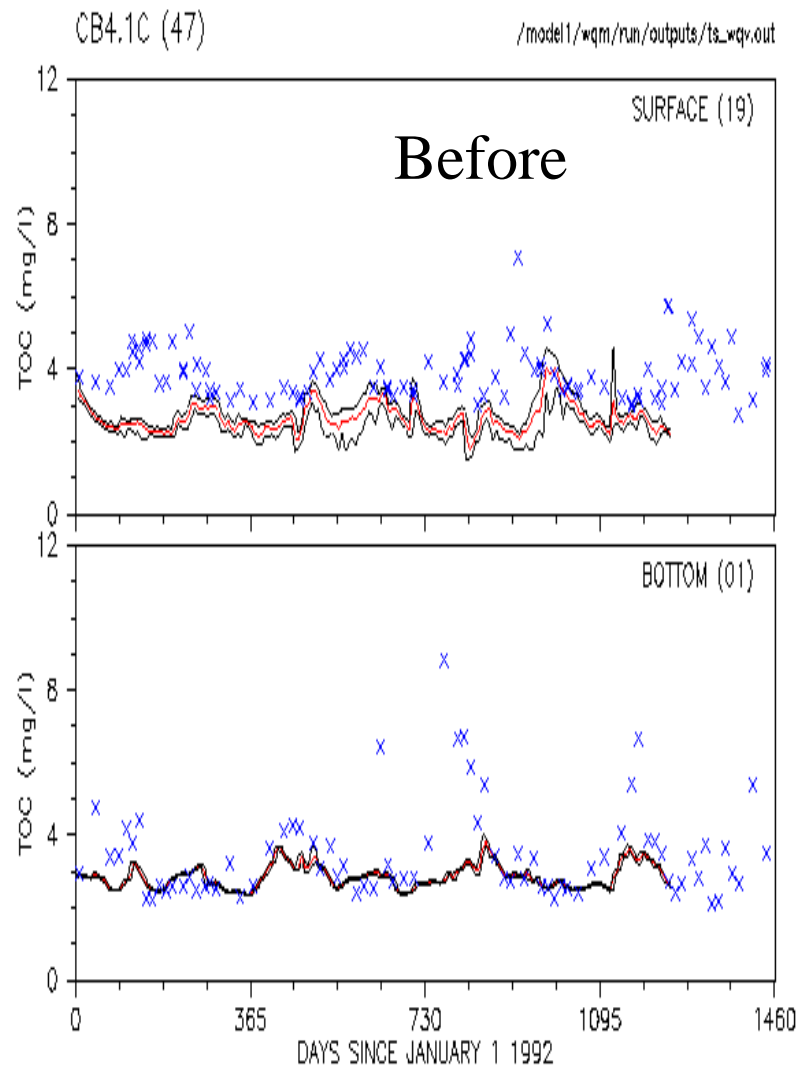




Eutrophication Model – Calibration

TOC vs. Resuspension

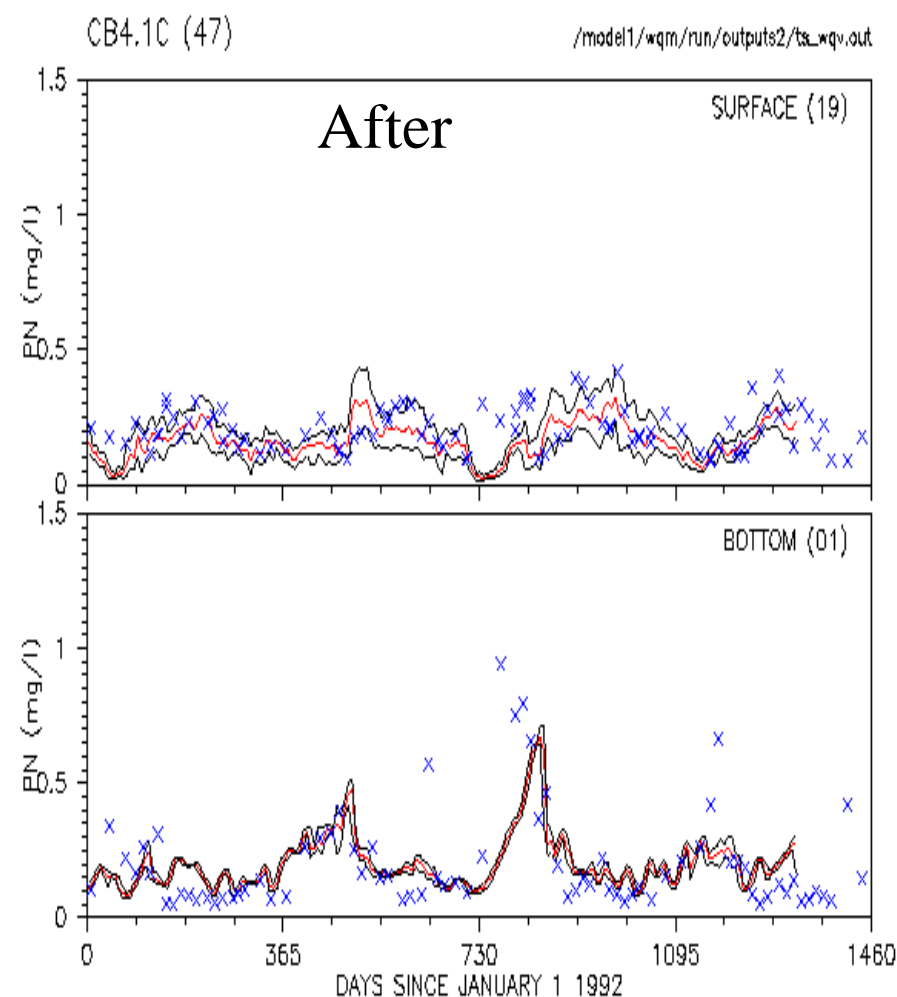
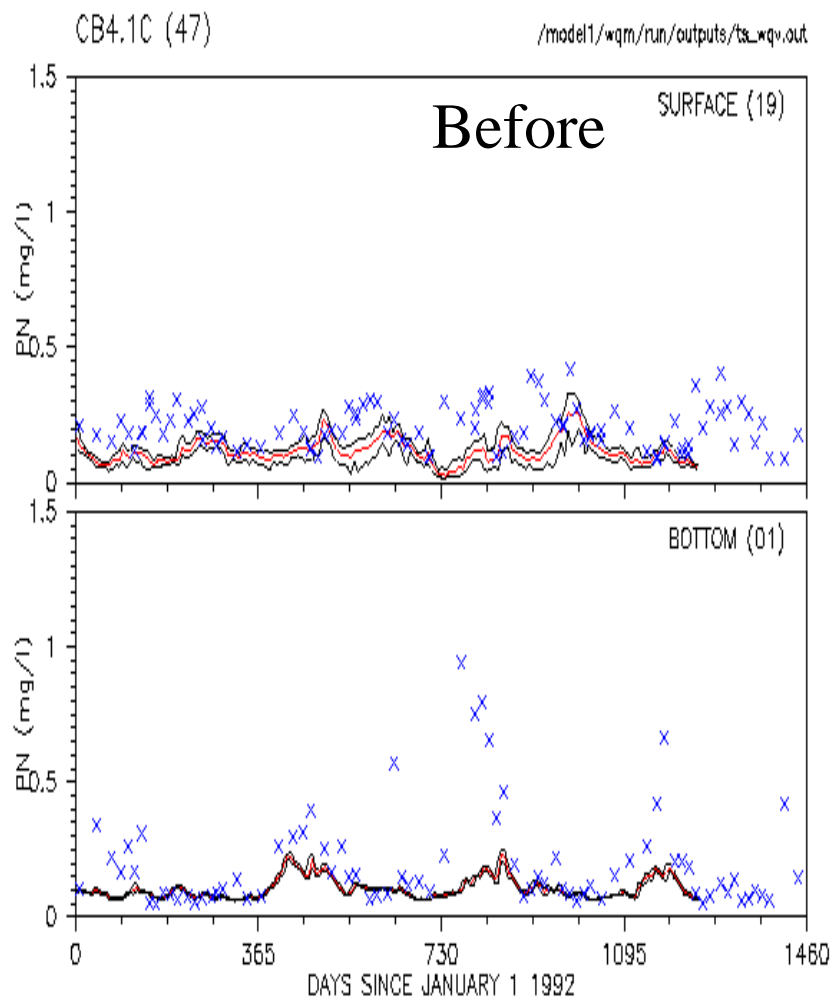
Bay





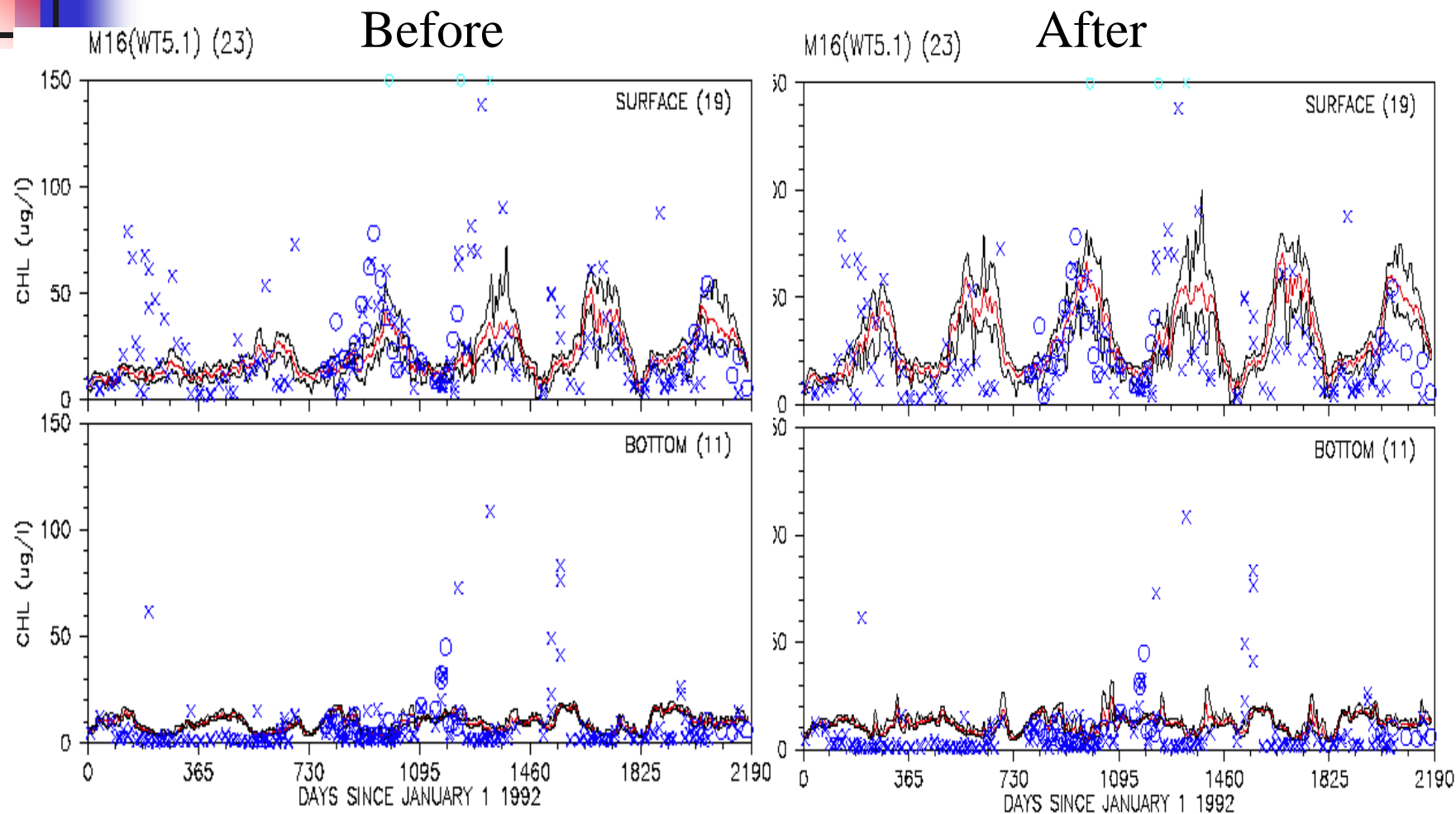
Eutrophication Model – Calibration

PN vs. Resuspension



Eutrophication Model – Calibration

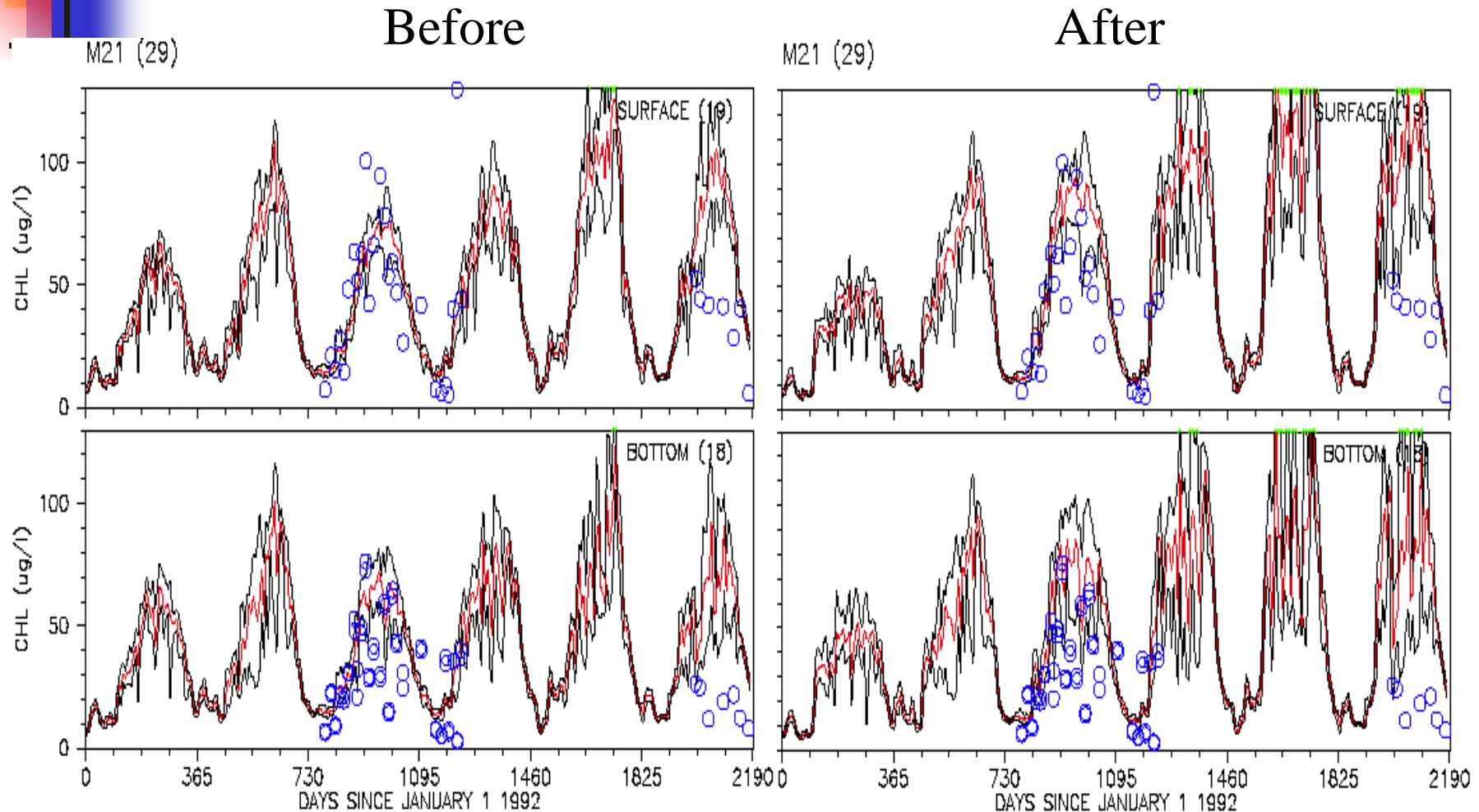
Chla vs. Sediment Initial Concentration + Zooplankton Grazing Rate
Harbor





Eutrophication Model – Calibration

Chla vs. Sediment Initial Concentration+Zooplankton Grazing Rate
Bear Creek



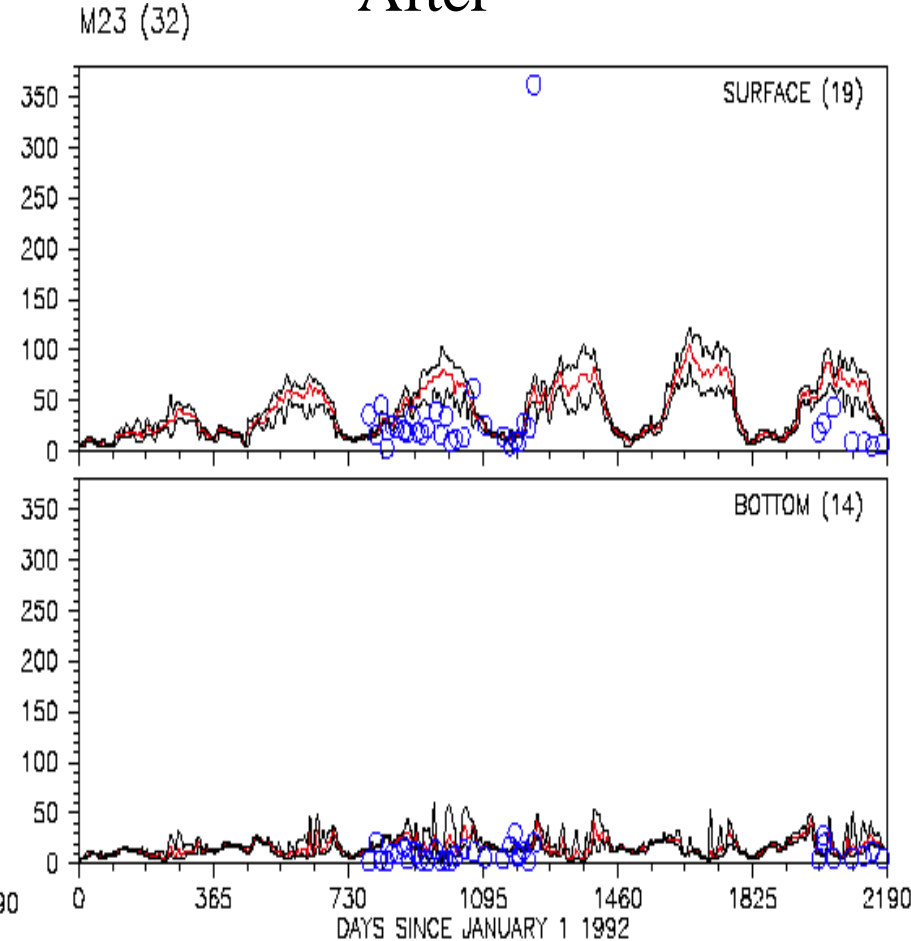
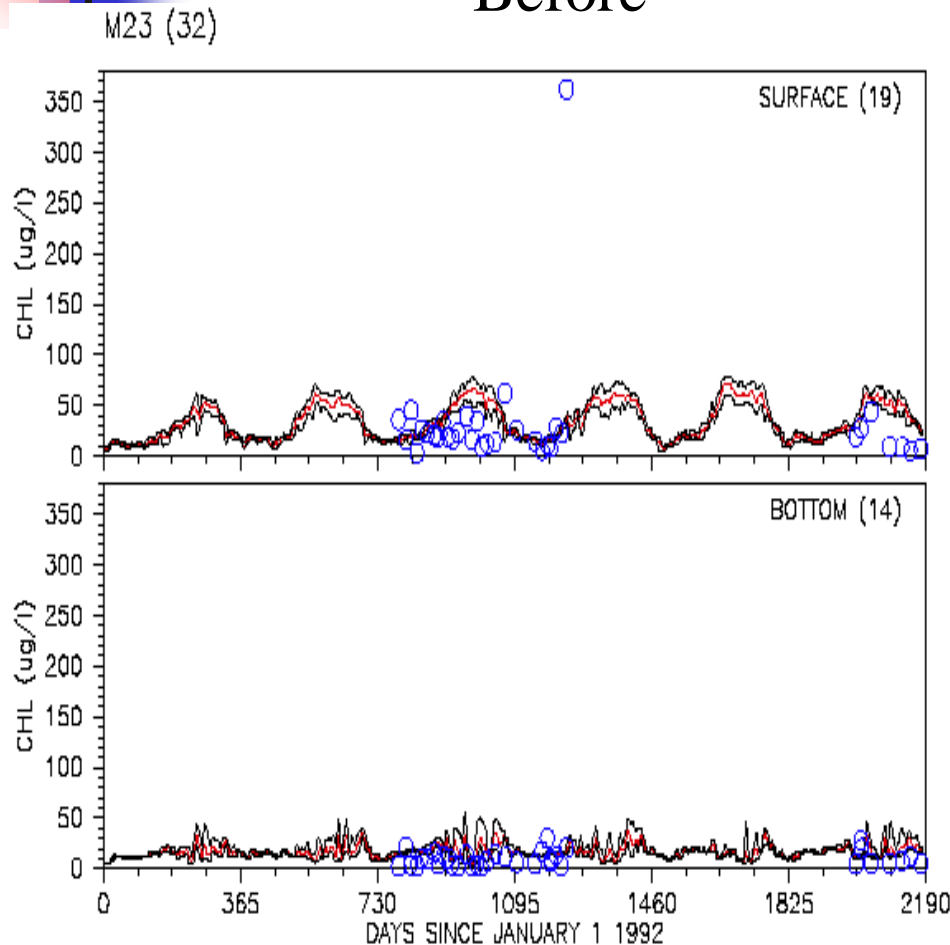


Eutrophication Model – Calibration

Chla vs. Sediment Initial Concentration+Zooplankton Grazing Rate
Curtis Creek

Before

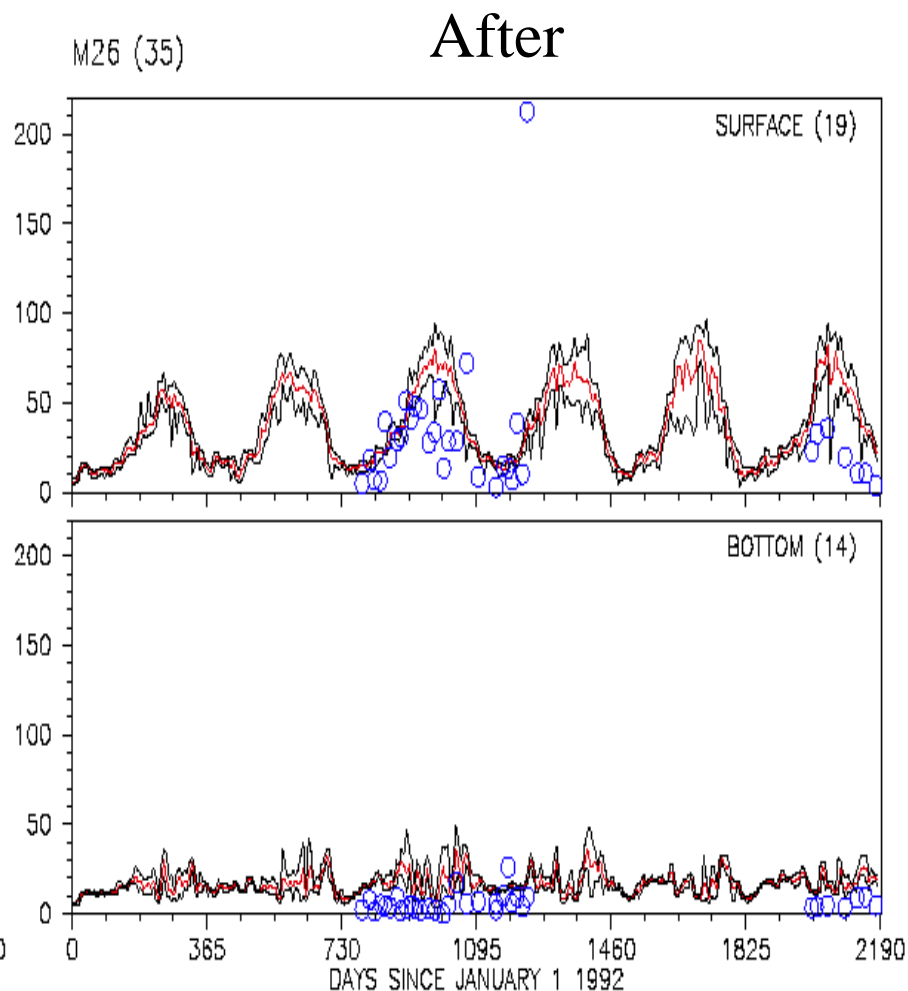
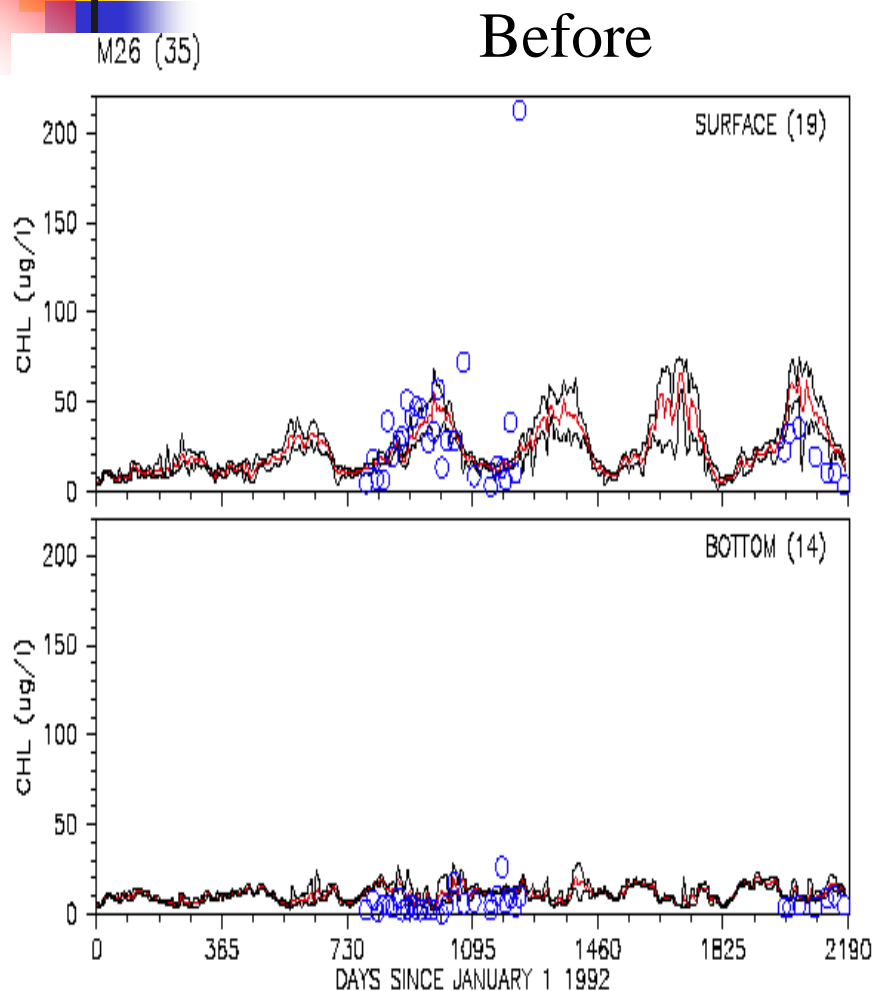
After





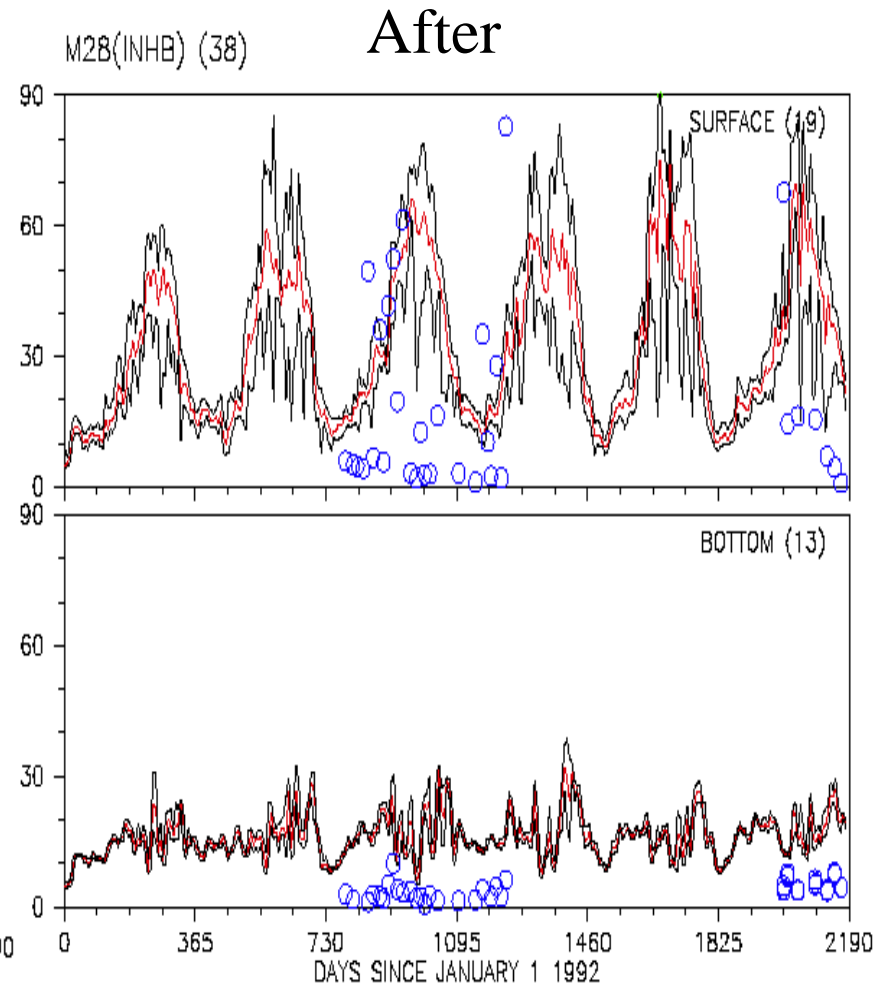
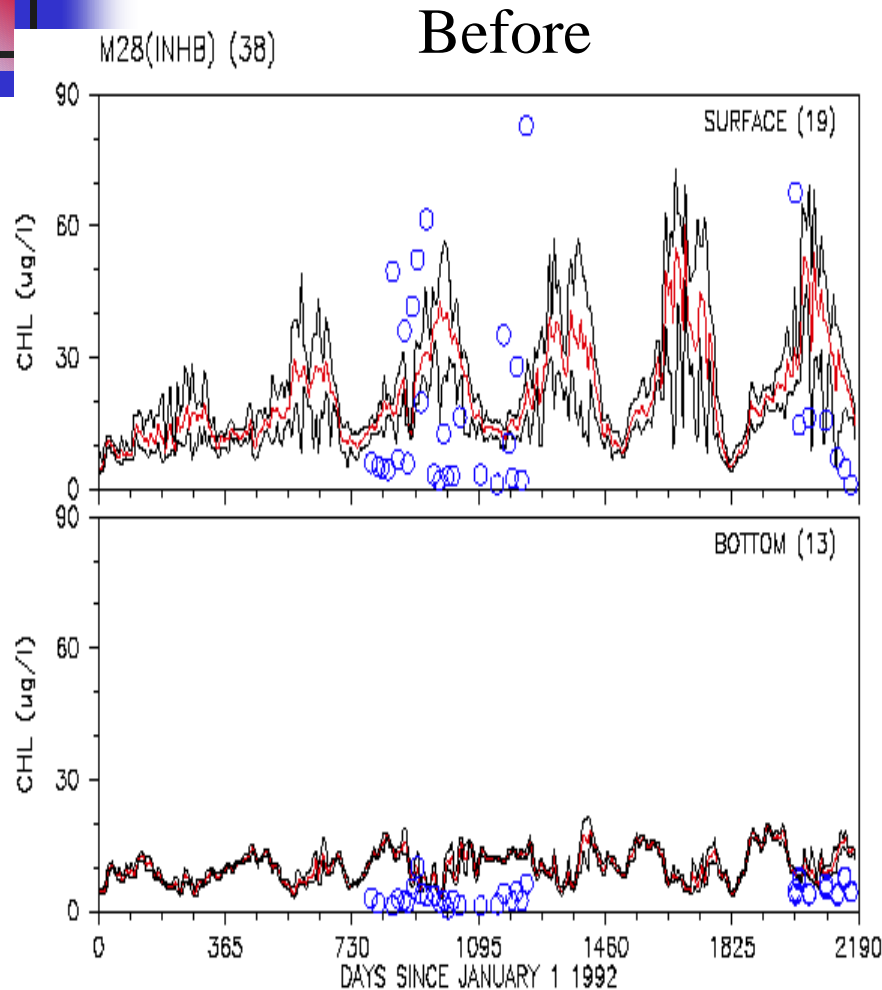
Eutrophication Model – Calibration

Chla vs. Sediment Initial Concentration+Zooplankton Grazing Rate
Middle Branch



Eutrophication Model – Calibration

Chla vs. Sediment Initial Concentration+Zooplankton Grazing Rate
Inner Harbor





Harbor Nutrient TMDLs: Progress/Future Actions

Progress to Date

- Point Source Loads
- Nonpoint Source Loads (HSPF)
- Harbor Hydrodynamic Model
- Harbor Water Quality Model

Future Actions

- Refine Calibration
- Model Sensitivity Tests
- Scenarios